Columbia River - Murphy Creek Project

Engineering Description

BC Hydro
Hydroelectric Generation Projects Division

Report No. H1565

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MURPHY CREEK PROJECT
ENGINEERING DESCRIPTION

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COLUMBIA RIVER
KEENLEYSIDE-MURPHY PROJECT
UPDATE

The Engineering Descriptions for the Keenleyside Powerplant Project (Report No. H 1560) and the Murphy Creek Project (Report No. H 1565) were prepared in November 1982 during the early stages of preliminary design. Since that time, on-going planning and design studies have resulted in some changes that would, to some extent, affect the project descriptions contained in these reports. The principal changes are as follows:

1. Construction Schedules

System Plan studies based on current load forecasts and alternative project sequences indicate earliest in-service dates of 1992 for Keenleyside and 1993 for Murphy Creek. The optional in-service date of 1990 mentioned in Report No. H 1560 for Keenleyside is no longer being considered.

2. Installed Capacities

Revisions to economic criteria may result in some reductions in the installed capacities selected for Keenleyside and Murphy. However, the changes are not expected to affect the arrangements or operation of the plants.

3. Keenleyside Turbine Setting

To improve flow characteristics in the powerplant and to maximize energy production in the pre-Murphy phase, the Keenleyside turbines

have been lowered by 3.0 m from El. 420 to El. 417. Due to improved cavitation characteristics this may also have a beneficial effect on fish passage.

4. Murphy Reservoir Shoreline Protection Works

Continuing geotechnical and property land use studies have resulted in small changes to the design and locations of shoreline protective works. Protective berms and fill is now considered as one of a number of possible mitigation options in low-lying and shallow sloping areas.

MURPHY CREEK PROJECT

COLUMBIA RIVER
MURPHY CREEK PROJECT
ENGINEERING DESCRIPTION

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SECTION 1.0 - INTRODUCTION

The proposed Murphy Creek Project is located on the Columbia River about 3 km upstream of the City of Trail, 23 km downstream of the confluence of the Columbia and Kootenay rivers and 33.7 km downstream of the Hugh Keenleyside Dam on the Columbia River.

Under the terms of the Columbia River Treaty between Canada and the United States three dams were constructed in Canada. The Mica and Hugh Keenleyside Dams were constructed on the Columbia River in Canada and the Duncan Dam was constructed on the Duncan River, a tributary of Kootenay Lake. In the United States the Libby Dam was constructed on the Kootenai River. The location of these projects is shown on Fig. 2-1.

The Murphy Creek Project with reservoir at El. 424 m would raise the Columbia River about 15 m at the project site and flood low terrace land upstream to Castlegar. The stability of the reservoir shoreline and the effect of the reservoir on adjacent properties have been key factors in establishing the reservoir levels for normal operation and flood conditions. The project would develop a maximum gross head of about 18 m between the project site and Hugh Keenleyside Dam; the minimum gross head would be 7 m. The project would add 300 MW of capacity to the B.C. Hydro system.

Prefeasibility and feasibility studies for the Murphy Creek Project were carried out between 1978 and 1980 (Ref. 1). Preliminary design studies commenced in 1981. Phase 1 preliminary design study of this project has included field investigations and office studies. The study has advanced sufficiently to permit preliminary decisions to be reached on the following project features and to allow a project cost estimate to be prepared.

1. Reservoir level.
2. Arrangement of structures.
3. Powerhouse arrangement and type of generating units.
4. Installed generating capacity and number of units.
5. Spillway type and hydraulic capacity.
6. Method and hydraulic capacity of river diversion during construction.
7. Type of embankment dam and seepage cut-off.

During the subsequent Phase 2 of preliminary design, all major project components will be optimized.

SECTION 2.0 - GENERAL DESCRIPTION

2.1 COLUMBIA RIVER DEVELOPMENT

The Columbia River system at the Murphy Creek Project site drains an area of 88,000 km^2 in southeastern British Columbia, northern Idaho and Montana (Fig. 1-1). The Columbia River has its source in Columbia Lake, in the Rocky Mountain Trench, and from there flows northwest and then south for a total of approximately 700 km to the Murphy Creek Project site. The Kootenay River, the major tributary to the Columbia River above the Murphy Creek site, originates in the Rocky Mountains, and flows south, west and then north for a total of approximately 500 km into Kootenay Lake. From Kootenay Lake, the river flows southwest for 30 km to its confluence with the Columbia River at Castlegar. A profile of the Columbia and Kootenay Rivers is shown on Fig. 2-1.

Existing storage projects on the Columbia River system upstream of the Murphy Creek Project provide over 31.3 x 10^9 m^3 of live storage. These comprise Mica Dam (14.8 x 10^9 m^3 of live storage) and Hugh Keenleyside Dam (8.8 x 10^9 m^3) on the Columbia River, Libby Dam (6.0 x 10^8 m^3) on the Kootenai River and Duncan Dam (1.7 x 10^9 m^3) on the Duncan River, a tributary of Kootenay Lake. The outlet of Kootenay Lake is regulated by the Corra Linn Project (Fig. 1-1). All other hydroelectric projects above the Murphy Creek site are run-of-river projects, with no significant live storage. The Revelstoke Project, presently under construction, will also be operated primarily as a run-of-river project.

Operation of 19.1 x 10^9 m^3 of storage at Mica, Hugh Keenleyside and Duncan projects is governed by Assured Operating Plans (AOP) prepared each year in accordance with Annex A of the Columbia River Treaty.

2.2 AREA DESCRIPTION

The Columbia River flows east from the Hugh Keenleyside Dam for about 9 km, then at Castlegar turns south just upstream of the confluence of the Kootenay River. Downstream of Castlegar the Columbia River flows south to the proposed project site some 3 km upstream of Trail. The Columbia River continues downstream of Trail, crossing the United States border just below the confluence of the Pend d'Oreille River. The town of Castlegar and a number of small communities and rural settled areas are adjacent to the river (Fig. 2-2). The river valley is characterized topographically by a series of alluvial terraces. The valley sides are well defined and steep, with bedrock outcrop and some forested areas.

A major highway and the Canadian Pacific Railway cross the Columbia River in Castlegar. A highway and rail line parallels the river on the west bank between Castlegar and Trail. This transporation corridor would be the main access to the project site.

2.3 RESERVOIR LEVEL

In the feasibility studies for the Murphy Creek Project (Ref. 1) project arrangements were developed for three reservoir levels, El. 424 m, El. 427 m and El. 430 m. A reservoir level of El. 424 m has been selected for further studies of the Murphy Creek development (Ref. 2). The lower (El. 424 m) reservoir level would limit the amount of flooded land and, combined with installation of power facilities at Keenleyside, would provide a power development close to optimum. With a reservoir level at El. 424 m, the Murphy Creek Project would raise the Columbia River approximately 15 m at the project site and approximately 4 m at the Hugh Keenleyside Dam; it would raise the Kootenay River approximately 3.1 m at the Brilliant Dam.

2.4 PROPOSED DEVELOPMENT

The Murphy Creek Project would have limited reservoir storage. The project would be designed and operated with average monthly outflows approximately equal to inflows as required to meet Columbia River Treaty requirements and load-factoring at the generating plant. The project would have a rated head of 13 m and an installed generating capacity of 300 MW. The proposed arrangement (Fig. 2-3) includes an earth/rockfill dam with till core in the river channel. The powerhouse would be located on the right bank housing five vertical shaft Kaplan units and a five-bay spillway would be between the powerhouse and the dam.

The main project structures on the dam axis would be located, at their closest point, approximately 200 m from the community of Oasis and approximately 500 m from the community of Rivervale. The existing highway and railway located between Oasis and the project site would be relocated (Fig. 2-3).

2.5 TRANSMISSION

Separate engineering studies are being prepared for the transmission line. Therefore, no engineering description of the transmission facilities for the Murphy Creek Project are included in this report.

SECTION 3.0 - RESERVOIR OPERATION AND FLOWS

3.1 RESERVOIR OPERATING REGIMES

Two Arrow Lakes Reservoir operating regimes have been considered in studies of the Keenleyside-Murphy Project.

Operating Regime 1 is essentially the existing regime for the Arrow Lakes Reservoir in which use is made, in most years, of close to the maximum available live storage. This results in a fairly long period, generally mid-January to mid-June, when the Arrow Lakes Reservoir is partially drawn down. Whenever the Arrow Lake Reservoir is partially drawn down, the Murphy Creek Reservoir would also have to be lowered to allow the required discharge capability at Keenleyside to be met. For the balance of the year the Murphy Creek Reservoir would be maintained as near as possible to the normal operating level of El. 424 m, as measured at the Castlegar Ferry water level gauge. This level would be subject to daily fluctuations required for operational purposes.

A summary of simulated monthly reservoir and tailwater levels at the Murphy Creek Project, and monthly discharges hydrographs, based on Regime 1 is shown on Fig. 3-1. A summary of the reservoir level profiles is shown on Fig. 3-2.

To maximize generation at Keenleyside and Murphy and to mitigate potential environmental impacts caused by reservoir drawdown, several alternative operating regimes for the Columbia River system with reduced Arrow Lakes drawdown have been investigated. One of these, termed Operating Regime 2, involves a reduction of the mean annual drawdown of the Arrow Lakes and an increase in the mean annual minimum reservoir level. Under this regime, the reservoir at Murphy would be generally at the normal operating level El. 424 m.

This level would be subject to daily fluctuations required for operational purposes.

A summary of simulated monthly reservoir and tailrace levels at the Murphy Creek Project, and monthly discharge hydrographs, based on Regime 2 is shown on Fig. 3-3. A summary of reservoir level profiles is shown on Fig. 3-4.

For most of the project life Regime 2 is expected to be much more representative of operation than Regime 1. For this reason Operating Regime 2 has been chosen as the basis for project design. When the operating flexibility of the Columbia River Treaty projects improves following expiration of the Treaty, it is expected that the operating regime may be further refined to increase power generation, improve flood control at Trail or reduce the environmental impacts of reservoir drawdown.

3.2 FLOOD FLOWS

The Probable Maximum Flood (PMF) for the Murphy Creek Project was estimated using watershed modelling of the basin (Ref. 3). Runoff conditions resulting in the PMF peak flow would be produced by the joint occurrence of an extremely high snowpack in early July, and a 20-day extreme warm temperature sequence (return period of 1000 years) starting 7 July. The weather sequence would be followed by the Probable Maximum Rain event at a time when the upstream reservoir had been filled so they would have limited flood control capability to attenuate the peak runoff. Under these conditions, a PMF peak of 13,100 m^3/s would be produced on 2 August at the Murphy Creek Project.

A regulated flood frequency study derived estimates for spillway design and diversion during construction floods (Ref. 4). The Spillway Design Flood was selected to have a return period of 200 years and limit flooding at Castlegar. The Diversion During Construction Flood was tentatively selected to have a return period of 30 years.

The results of these studies were:

Spillway Design Flood	7,590 m^3/s.
Diversion During Construction Flood	6,310 m^3/sec

The spillway would be designed to pass the Spillway Design Flood, with the reservoir level at Castlegar approximately 0.2 m above the river level that would have occurred naturally for the same flood without the Murphy Creek Project. This level would be approximately 1.5 m above the normal operating level for the Murphy Creek project. There would be no damage to the spillway.

The spillway would also be designed to pass the Probable Maximum Flood with the reservoir level at Castlegar approximately 0.7 m above the regulated PMF river level that would have occurred naturally without the Murphy Creek Project. There might be some limited damage to the spillway and other structures under this extreme flow conditions.

Backwater profiles for mean annual flow, Spillway Design Flood and Probable Maximum Flood are shown on Fig. 3-5 for the Murphy Creek project and existing river condition.

SECTION 4.0 - PROJECT FEATURES

4.1 SPILLWAY

The concrete spillway would be located on bedrock between the powerhouse and embankment dam (Fig. 2-3, 4-1) and would have an ogee crest. Flow through the five bays would be controlled with radial gates. The spillway would be capable of discharging the spillway design flood with a reservoir level at the structures at El. 418.25 m and the PMF with a reservoir level at El. 424.23 m (Fig. 3-5). The freeboard allowance under normal operating and PMF flood conditions would be over 4 meters.

4.2 GENERATING FACILITIES

a. Powerhouse

The powerhouse would be located on the right bank of the river with excavated approach and tailrace channels (Fig. 2-3). A typical section through the powerhouse is shown on Fig. 4-1. The indoor machine hall would be approximately 155 m long and the service bay 46 m long. Two overhead bridge cranes would have a capacity of about 275 tonnes each. Access to the powerhouse would be from the Trail-Castlegar Highway, adjacent to the service bay.

b. Powerplant Capacity

The installed generating capacity would be 300 MW. This capacity was selected following an economic study in which both the power output of the turbines and the generator capacity were optimized to produce the highest net annual benefits. On the basis of this optimization study and considering the limits

of current experience with large size Kaplan units at heads similar to that at Murphy Creek, five vertical shaft Kaplan units would be installed. Each would have a rated output of approximately 61,200 kW under a rated net head of 13.0 m.

c. Intakes

The intakes would be integral with the powerhouse and, for each unit, would comprise three water passages separated by piers. The piers would have trashracks at the upstream face, guides for service bulkheads or stoplogs, and hydraulically controlled operating gates. This equipment would be serviced by a gantry crane. An 8½ tonne capacity jib crane, attached to the gantry crane, would be used in conjuction with a hydraulic grapple for removal of debris.

d. Turbines

The five turbines would be vertical shaft Kaplan units operating at 63.2 rpm and developing the rated output of 61,200 kW at a rated net head of 13.0 m. The rated discharge of each unit would be approximately 525 m^3/s. The combined five-unit discharge of 2625 m^3/s is about 30 percent higher than the long-term average flow (2050 m^3/s) of the Columbia River at the Murphy Creek damsite. It has been assumed that the plant would be shut down when the gross head is less than 7.0 m. Future studies will be made on the use of fixed blade propeller turbines instead of Kaplan turbines for some or all of the units.

e. Electrical Equipment

The five generators would be of the umbrella or semi-umbrella type, having a sychronous speed of 63.2 rpm. The rated capacity

would be 60 MW at a 0.90 power factor and a primary voltage of 13.8 kV, corresponding to the rated turbine output. Each generator would be connected by a naturally cooled isolated phase bus to a three phase generator transformer rated at 67 MVA, 13.8 kV.

Low voltage generator circuit breakers would be located in the downstream gallery between the generators and generator transformers.

The generator transformers and 230 kV switchgear would be located on the tailrace deck. The 230 kV swithchgear would consist of high voltage circuit breakers, disconnect switches, ground switches and bushings, all metalclad and compressed gas (SF6)insulated. This switchgear would be connected to 230 kV overhead transmission lines terminated on the downstream side of the powerhouse roof.

Station service would be provided from taps off the low voltage buses at 13.8 kV from each unit.

f. System Control

The Murphy Creek Powerplant would be remotely controlled through the B.C. Hydro microwave system from the Cranbrook Control Centre and from the Burnaby Mountain System Control Centre near Vancouver. It would be linked with the microwave system by a passive reflector.

4.3 EMBANKMENT DAM

The embankment dam would have a zoned earth-rockfill section consisting of an impervious central core, compacted rockfill shells and filters, with transitions and drains composed of processed granular material.

The zoned earth-rockfill section would be placed between the rockfill cofferdam sections which create second stage diversion (section 6.5). The rockfill cofferdam sections would be incorporated into the toes of the embankment dam. The embankment dam would be about 150 m long and up to 28 m high. A typical section through the embankment dam is shown on Fig. 4-1.

A cutoff wall would be required to reduce seepage and to prevent possible migration of fine material from or within the alluvial foundation material. This would comprise concrete diaphragm cutoff wall to a maximum depth of about 90 m to bedrock, and extending about 250 m into the left abutment to seal the buried channel. In order to reduce the height of the cutoff wall, the alluvial gravel terrace would be excavated down to dam crest level. The excavated materials would be used for construction materials where suitable.

SECTION 5.0 - RESERVOIR

5.1 AREA AND VOLUME

At the normal operating level, El. 424 m, the area of the reservoir would be about 1300 ha. The volume of the reservoir at the normal operating level, El. 424 m, would be about 140 million m^3.

The reservoir area and volume in relation to surface elevation is illustrated on Fig. 5-1.

The reservoir would extent to Hugh Keenleyside Dam on the Columbia River and Brilliant Dam on the Kootenay River. The total flooded area would be approximately 302 hectares, measured between the average annual high water level under existing conditions and the normal operating reservoir level.

5.2 RESERVOIR BANK STABILITY

The riverbank between the proposed damsite and Hugh Keenleyside Dam has been investigated and the soil conditions and bank stability evaluated.

The riverbank consists of fine grained silt and granular materials including sand, gravel and cobbles and in some areas these materials stand relatively steeply (1 vertical to 1.2 horizontal) and are likely to be unstable and subject to ravelling. As these banks erode they develop beach slopes near the present river level. Coarse gravel, cobbles and boulders pave the existing beach slopes.

The riverbank has been studied to assess reservoir shoreline regression (Ref. 5). Terrain analyses indicate that the main cause of any shoreline regression following filling of the reservoir would be

beaching and ravelling due to wave action, rather than any "deep-seated" sliding. Based on this conclusion, shoreline regression has been estimated using long-term (75 to 100 year period) beach slopes for the various materials along the proposed reservoir shoreline. The beach slopes were determined using information obtained from an Arrow Lakes Reservoir study. A study of wind duration at various reservoir elevations indicated that most beach erosion would occur with the reservoir at the normal operating level (El. 424 m).

In areas where river banks are steep, the reservoir shoreline study concluded that formation of beach slopes would be accompanied by regression of the banks behind the beach until a stable condition was reached. The amount of regression of very steep banks behind the beach was based on developing a generalized stable slope assumed to be 1 vertical to 1.5 horizontal. Based on this postulated mode of regression, a preliminary safeline was developed.

5.3 SHORELINE PROTECTION WORKS

The shoreline has also been studied to determine which portions would need to be protected from inundation and/or erosion. In most areas where the preliminary safeline would otherwise encompass residences, commercial buildings, rail lines, roads, sewage lagoons and cemeteries, shoreline protection works would be built. These protective works would limit the impact of the reservoir and a reservoir impact line was developed. Shoreline protection works would be provided before reservoir filling in all cases except for roads which would be protected after reservoir filling if significant erosion occurred. The protection works would be rock and/or granular fill toe protection along the river banks and protective berms and fill in low-lying and shallow-sloping areas. The proposed location of reservoir shoreline protection works has been evaluated by comparing preliminary costs of the protection works to the estimated value of property. Fig. 5-2 shows the proposed locations of these

shoreline protection works and typical sections. However, the proposal for berms and fill protective works in the low-lying and shallow sloping areas would be subject to agreement by property owners.

5.4 INFRASTRUCTURE

Municipal infrastructure has been studied to determine what remedial works would be necessary to rehabilitate or replace facilities which would be impacted by the reservoir (Ref. 6). Infrastructure that would be impacted includes water supply and sewage works, storm drainage and local roads located in Robson, East Raspberry, Ootischenia, North Castlegar, South Castlegar and China Creek.

5.5 UTILITIES

Utility facilities which would be impacted by the reservoir are:

1. WKPL transmission lines (main & distribution).
2. B.C. Telephone, telephone/cable lines.
3. C.P. Telecommunications, cable lines.
4. Inland Natural Gas, pipeline.

In the project area, utilities cross the river and are located along the shorelines. The impacted crossings would be rehabilitated to conform to regulatory clearance requirements. Towers, poles and other structures would be relocated beyond the reservoir impact line. There are 13 utility crossings of the Columbia River in the project area, 4 crossings of the Kootenay River and 1 crossing of Pass Creek of which 13 would be impacted. These are shown on Fig. 5-3.

The buried Inland Natural Gas pipeline in North Castlegar would be submerged in certain areas. The buried pipeline would be protected, weighted to counteract buoyancy, and its valves and controls raised.

The reservoir would inundate a portion of the West Kootenay Power & Light transmission line which runs adjacent to the shoreline at Waterloo Eddy, just downstream of Ootischenia. The inundated poles would be raised, fill placed around them and this fill protected from erosion.

A section of the 8 pole 60 kV transmission line owned by West Kootenay Power & Light and Cominco, located near the project site, would be temporarily relocated during construction. Following relocation of the highway and rail line, the transmission line would be rebuilt along its original right-of-way. The poles would be located to provide adequate clearance for crossing of the highway and rail line (Fig. 2-3).

5.6 HIGHWAYS

A portion of the highway between Trail and Castlegar would be relocated around the project structures (Fig. 2-3). The relocated length would be less than 1 km.

The highway between Robson and the Keenleyside Dam would be monitored after filling of the reservoir and protection would be placed as required if substantial erosion occurred. The area is easily accessible to allow placing of protection materials from the road.

The gravel road between Ootischenia and Champion Creek would be raised to above the reservoir impact line and protected for a length of about 1.2 km.

A limited amount of protection works would be required for the abutments of the highway bridge in Castlegar.

5.7 CANADIAN PACIFIC RAILWAY

The rail line would be relocated around the project structures (Fig. 2-3).

Approximately 5.4 km of rail line between Birchbank and the project site would be raised, while maintaining rail traffic, and the Murphy Creek crossing and the Birchbank siding would be rebuilt (Ref. 7).

5.8 BC TIMBER

The reservoir would affect the existing shoreline protection works at the BC Timber Pulpmill and Sawmill which is located downstream of the Keenleyside Dam on the right bank of the Columbia River (Fig. 2-2). The existing protection works would be upgraded and extended (Ref. 8).

SECTION 6.0 - CONSTRUCTION

6.1 CONSTRUCTION SCHEDULE

The construction schedule shown on Fig. 6-1 is based on an in-service date of 1993. The schedule shows a construction period of 5½ years from award of the first contract in the spring of 1988 to bringing the first two units in service by October 1993. Additional units would come on line at intervals of four months. Diversion through the spillway would commence 3½ years after award of the first contract.

6.2 SEQUENCE OF CONSTRUCTION

The construction sequence is shown on Fig. 6-2.

Following relocation of the highway, railway and powerlines around the project structures, construction would begin in the spring of 1988 under the first civil contract for development of site access, camps and work areas (Phase A). Initial excavation for the approach and tailrace channels would start in the summer of 1988 and continue through the spring of 1989. Construction of the cellular cofferdam would start in the spring of 1989.

The second civil contract would be awarded in the summer of 1989 with excavation for the powerhouse and spillway (Phase B). Excavation on the left bank for the concrete diaphragm wall would commence in the fall of 1989 with construction of the wall starting in the spring of 1991. Concrete placement for the powerhouse and spillway structures would start in the spring of 1990 (Phase C). Excavation for the approach and tailrace channels would be completed and the spillway ready for diversion in late fall 1991.

Prior to diversion an earth/rockfill cofferdam would be constructed around the uncompleted powerhouse or rock plugs left in place. For diversion, channel rock plugs and part of the cellular cofferdam would be removed. Rockfill dykes would be constructed in the river channel and the cellular cofferdam removal would be completed after diversion (Phase D). The embankment dam would be constructed during 1992 and the diaphragm wall under the dam constructed with the fill partially completed. Installation of the turbines would start in the fall of 1991 with the first two units in service by October 1993 (Phase E).

Placement of reservoir bank protection, and berms and fill in low-lying areas would start in 1991 and be completed prior to reservoir filling. The railway line upstream of the site would be raised and all infrastructure that would require raising or relocation would be completed prior to reservoir filling in spring 1993.

6.3 CONSTRUCTION METHODS AND PLANT

The methods and equipment employed for construction of the project would be the Contractor's choice. However, construction practices would be controlled to ensure a minimum impact on the surrounding environment. For planning purposes, the following assumptions have been made as to the construction methods.

The main activities for the first civil contrator would be excavation of overburden and rock for the approach and tailrace channels by drilling and blasting, and loading and hauling to spoil areas, development of the site, the construction of the cellular cofferdams and widening of the river channel in the wet.

The main activities of the second civil contractor would be excavation, concrete placing and fill placing. The overburden and rock excavation for the powerhouse, spillway and channels would be completed as well as the overburden excavation for the concrete diaphragm wall. Approximately 3 million cubic meters of rock and 2 million cubic meters of overburden would be excavated. Spoil areas would include the right bank of the river upstream of the project and Billy Creek. Approximately 360,000 cubic meters of concrete would be batched and placed, mainly in the powerhouse and spillway. Channel rock plugs and part of the cellular cofferdam would be removed in the wet and the rockfill dykes constructed in the river channel. Approximately 180,000 cubic meters of rockfill and 70,000 cubic meters of earthfill would be placed for construction of the embankment dam and dykes. The powerhouse cofferdam or rock plugs would be removed partially in the wet prior to reservoir filling.

The concrete diaphragm wall would be constructed using specialized equipment and methods suitable for walls of this depth and in this material.

Materials for the impervious core of the earthfill dam would be obtained from till deposits along the left bank of Murphy Creek approximately 4 km from its confluence with the Columbia River (Fig. 6-3). The volume of impervious fill material required would be about 22,000 m^3 and the haul distance would be about 9.5 km.

Materials for concrete aggregate, granular fill, transitions and drains would be excavated from the left bank of the river close to the axis of the structures (Fig. 6-3). Materials from the excavation for the left abutment concrete diaphragm wall may be utilized if suitable. The volume of processed granular material required would be approximately 540,000 m^3.

Materials for rockfill and riprap for the dam and dykes would be obtained from the rock excavation operations. Materials for reservoir shoreline protection works would be obtained from rock excavation operations or oversize material from granular borrow pits.

6.4 CONSTRUCTION CAMP

The offices and single labour camp would be located on the right bank of the river downstream of the project structures and just upstream of Hanna Creek (Fig. 6-3). This location would provide good access to all work areas. The single labour camp would accomodate up to 600 persons at the peak of construction. The proposed camp would comprise 8 two-storey 80-man bunkhouses, dining and kitchen facilities for 800 men, recreational hall, and parking stalls for 325 vehicles. The camp would be managed by B.C. Hydro with contract caterers.

Offices for B.C. Hydro would be provided adjacent to the camp with parking stalls for 30 vehicles. Full services would be provided for the complex including water, sewage, electricity, gas, and telephone. Water would be obtained from the Columbia River and treated before use. Sewage would be treated in a package plant and effluent discharged into the Columbia River. Electric power would be obtained from West Kootenay Power and Light.

6.5 RIVER DIVERSION

The proposed sequence for river diversion is shown on Fig. 6-2. Initial construction work would involve rock excavation for the approach and tailrace channels on the right bank of the river. During this phase of the work no diversion is required.

First stage diversion would direct the Columbia River to the left bank of the existing river channel by a cellular cofferdam. The cellular cofferdam would be about 240 m long and each cell would be 15.5 m in diameter, requiring 15 cells, and up to 26 m in height. It would be necessary to widen the river channel by excavating and protecting the left bank to maintain acceptable water levels during diversion. Powerhouse and channel excavations would be protected by upstream and downstream rock plugs.

Second stage diversion would comprise two rockfill dykes in the existing river channel diverting flow through the completed spillway. Upstream and downstream channel rock plugs and the cellular cofferdam would be removed. An earth/rockfill cofferdam would be constructed around the uncompleted powerhouse or rock plugs left in place.

SECTION 7.0 - PROJECT OPERATION

7.1 RESERVOIR OPERATION

Over the life of the Murphy Creek Project, operation of the Arrow Lakes Reservoir would vary from the existing conditions, approximated by Regime 1, to future conditions approximated by Regime 2. The operation of the Columbia River system will gain additional flexibility when the Columbia River Treaty expires (2024), and at that time it may be possible to further refine the operating regime to improve power generation and flood control or reduce environmental impacts of reservoir drawdown.

The project design has been based on Operating Regime 2. As there is no certainty that this regime would be in effect immediately following completion of the project, it has been assumed that there would be a period with the project operating under Regime 1.

7.2 RESERVOIR FLUCTUATIONS

Daily fluctuations of reservoir water level at the dam for generation of electrical energy would be limited to 2.0 m during March and April of each year and 1.5 m in other months. Daily fluctuations upstream of the dam would be slightly less, depending on location and inflow.

Seasonal fluctuation of reservoir level based on simulated monthly flows for Regime 1 are shown on Fig. 3-2. Seasonal fluctuation of reservoir level based on simulated monthly flows for Regime 2 are shown on Fig. 3-4.

7.3 DOWNSTREAM CONDITIONS

The minimum flow downstream of the project would be maintained at 425 m^3/s under normal operating condition. However, Columbia River flows less than 425 m^3/s could be requested by the U.S. to meet Columbia River Treaty requirements.

In the event of a complete plant load rejection, the spillway gates would open automatically to reinstate flow. Consequenty, there would be only a minor effect on downstream flows and water levels.

Daily fluctuations of tailwater level at the dam for operational purposes would be limited to 3.0 m, with an hourly variation limited to 1.0 m.

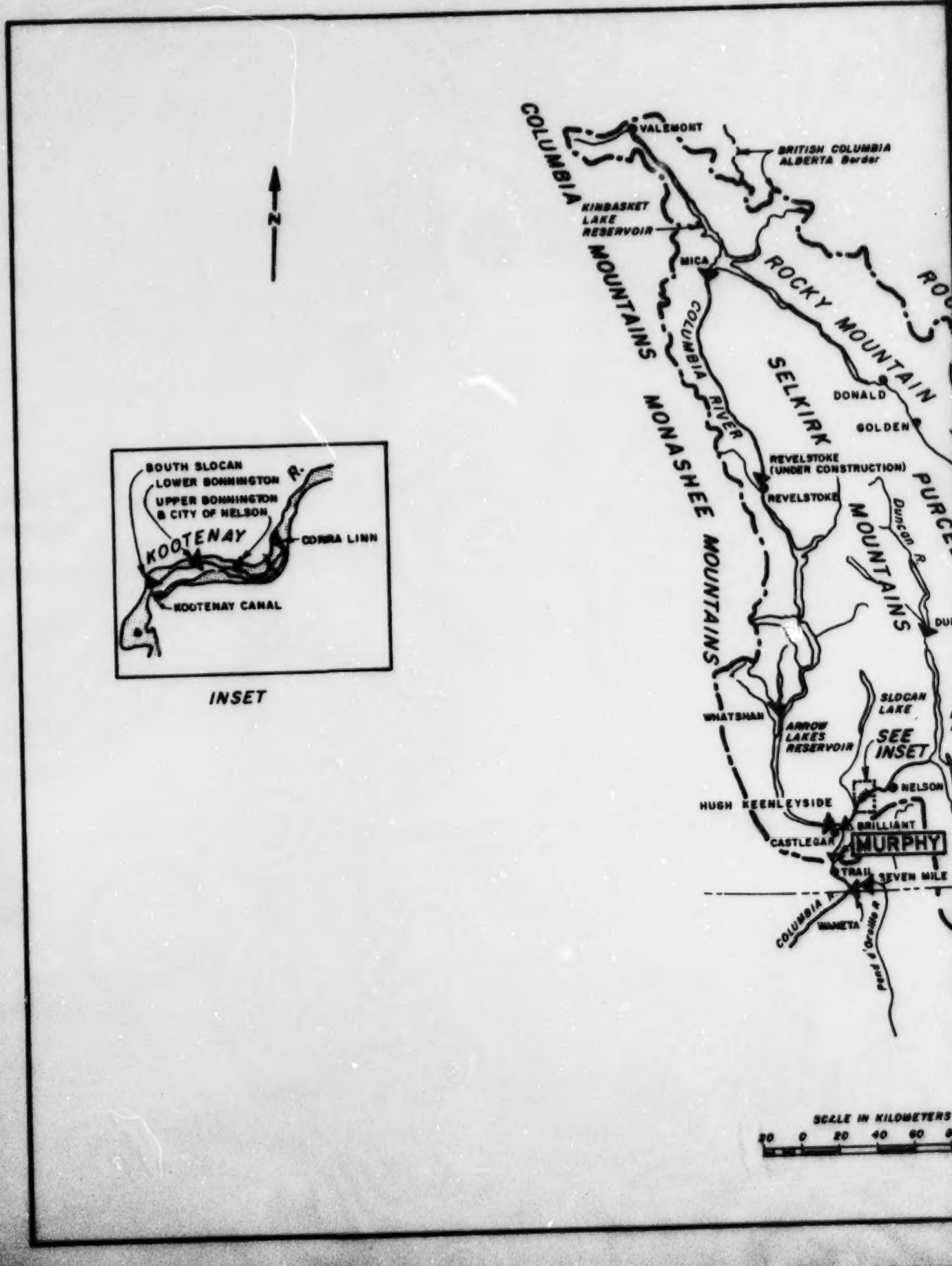
7.4 GENERATION

With the limited reservoir storage available, the project would be operated with average monthly outflow approximately equal to inflows. Based on the regulation and simulation of monthly flow records from 1940 to 1975, the average annual discharge at the Murphy Creek Project site available for power generation would be 2050 m^3/s. The proposed installed plant hydraulic capacity of 2625 m^3/s would utilize 96% of the energy available in the river under Regime 2. The average annual spill would be 100 m^3/s. The months that this spill would most likely occur are January, February and May, June and July.

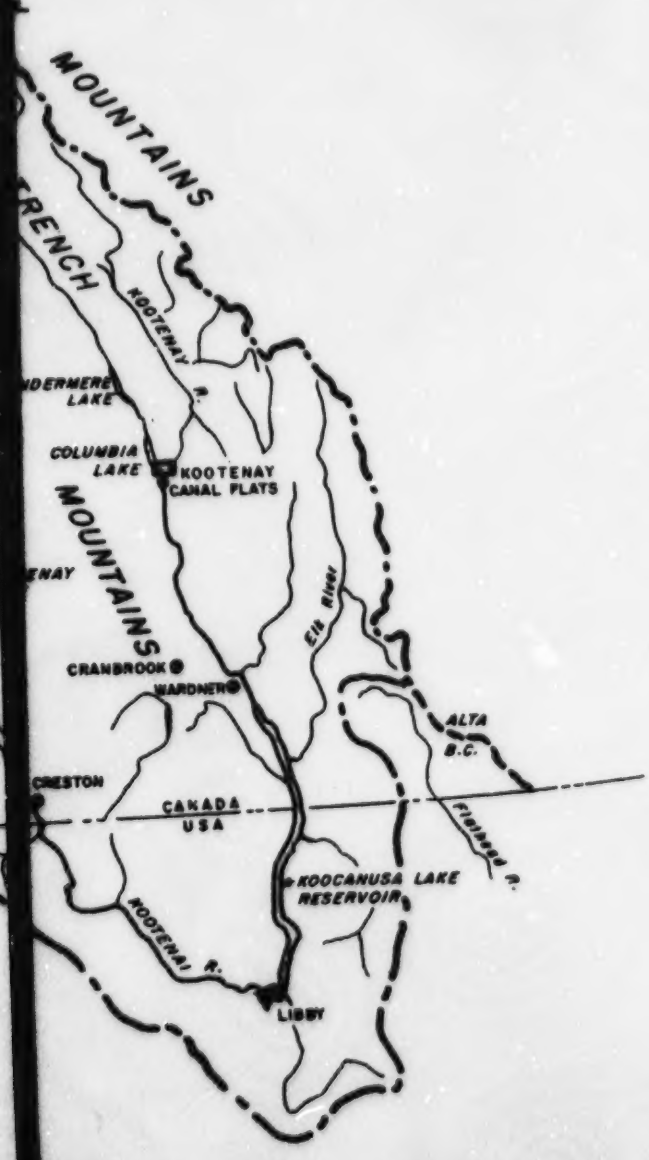
Under Operating Regime 2, the average annual gross energy production at the project with the 300 MW installed capacity would be about 2115 GWh. Losses at the existing Brilliant powerstation would be approximately 145 GWh which would provide a net energy production of approximately 1970 GWh.

Under Operating Regime 1, the average annual gross energy production at the project with the 300 MW installed capacity would be 1705 GWh. Losses at the existing Brilliant powerstation would be approximately 115 GWh which would provide a net energy production of approximately 1590 GWh.

Potential losses at the proposed Keenleyside powerplant have not been deducted from the net energy production at Murphy. The Keenleyside powerplant and Murphy Creek are considered as a combined project.


N
SOUTH SLOCAN
LOWER BONNINGTON
UPPER BONNINGTON
& CITY OF NELSON
KOOTENAY R.
CORRA LINN
KOOTENAY CANAL
INSET
COLUMBIA MOUNTAINS
VALEMONT
BRITISH COLUMBIA
ALBERTA Border
KINBASKET
LAKE
RESERVOIR
MICA
COLUMBIA RIVER
ROCKY MOUNTAIN
SELKIRK
MONASHEE MOUNTAINS
DONALD
GOLDEN
REVELSTOKE
(UNDER CONSTRUCTION)
REVELSTOKE
Duncan R.
MOUNTAINS
WHATSHAN
ARROW
LAKES
RESERVOIR
SLOCAN
LAKE
SEE
INSET
NELSON
HUGH KEENLEYSIDE
BRILLIANT
CASTLEGAR
MURPHY
TRAIL
SEVEN MILE
COLUMBIA R.
WANETA
SCALE IN KILOMETERS
20 0 20 40 60

KEY PLAN



LEGEND:

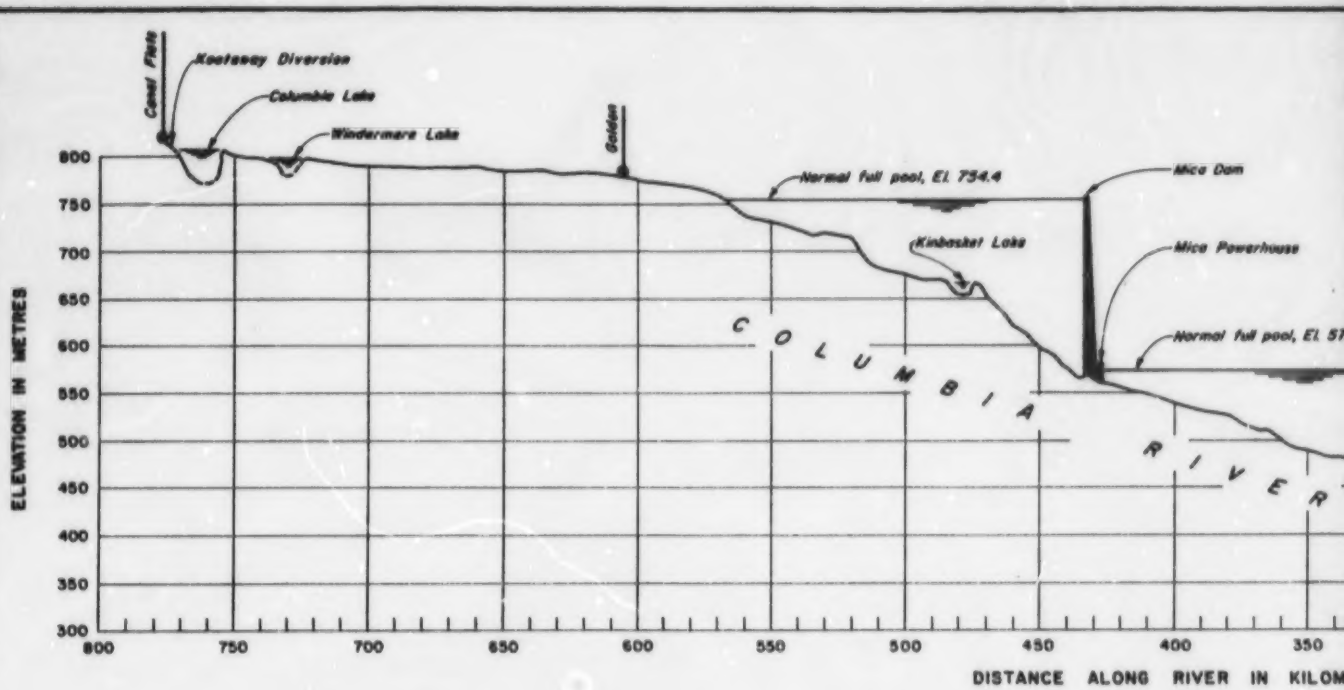
- City, town, or settlement
- Existing dam
- Proposed dam
- Potential diversion
- Limit of drainage basin

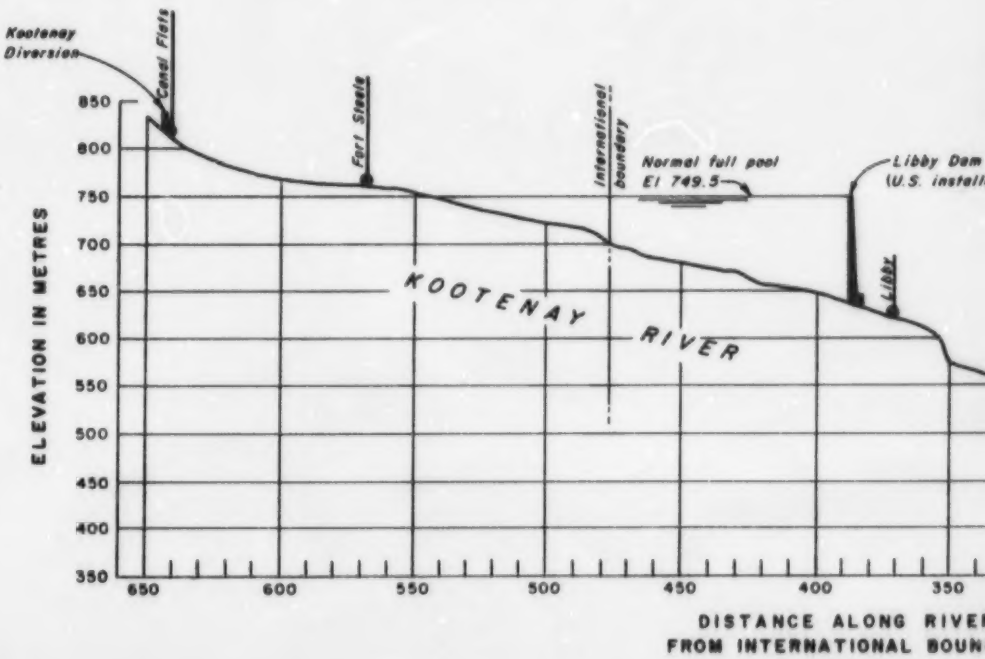
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

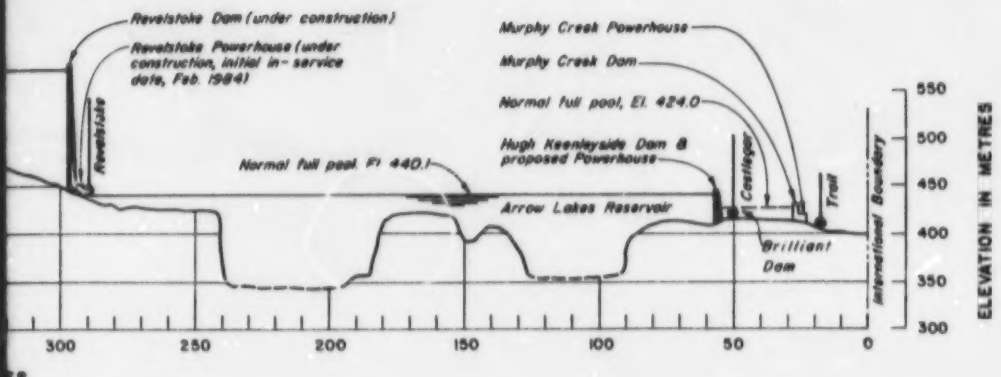
COLUMBIA RIVER – MURPHY CREEK PROJECT

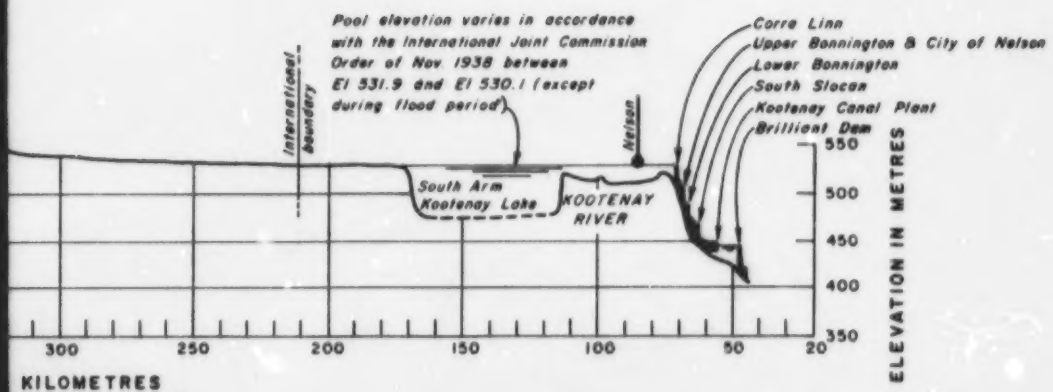
KEY PLAN AND DRAINAGE BASIN

DATE NOV 1982	FIG. 1-1
DWN MWB	DWG. No. 218-C14-B418


Canal Flats
Kootenay Diversion
Columbia Lake
Windermere Lake
Golden
Normal full pool, El. 754.4
Mica Dam
Kinbasket Lake
Mica Powerhouse
Normal full pool, El. 5
COLUMBIA
RIVER
ELEVATION IN METRES
800
750
700
650
600
550
500
450
400
350
300
800
750
700
650
600
550
500
450
400
350
DISTANCE ALONG RIVER IN KILOM


Kootenay
Diversion
Canal Flats
Fort Steele
International
boundary
Normal full pool
El 749.5
Libby Dam
(U.S. install
Libby
KOOTENAY
RIVER
ELEVATION IN METRES
850
800
750
700
650
600
550
500
450
400
350
650
600
550
500
450
400
350
DISTANCE ALONG RIVE
FROM INTERNATIONAL BOUN



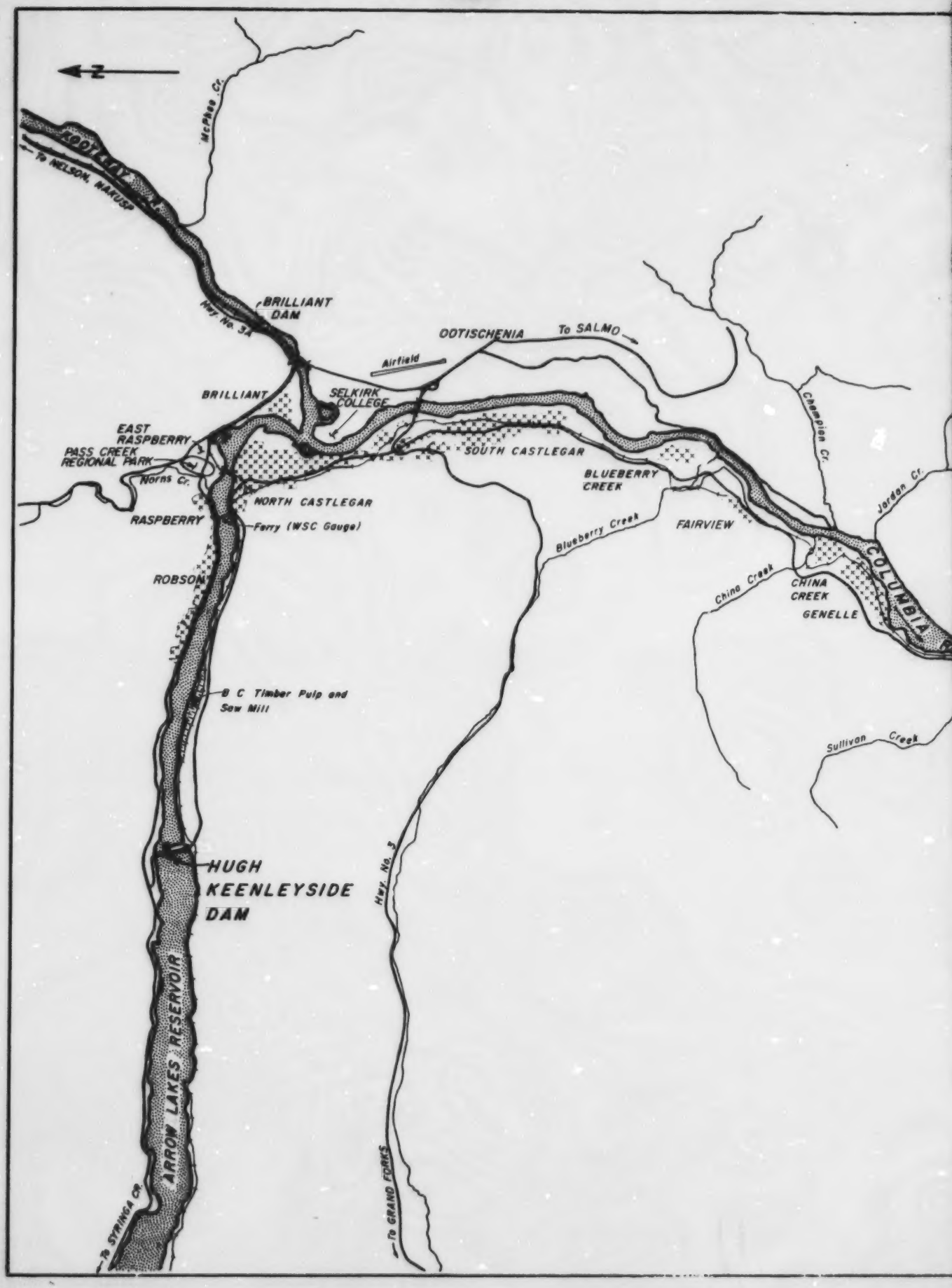


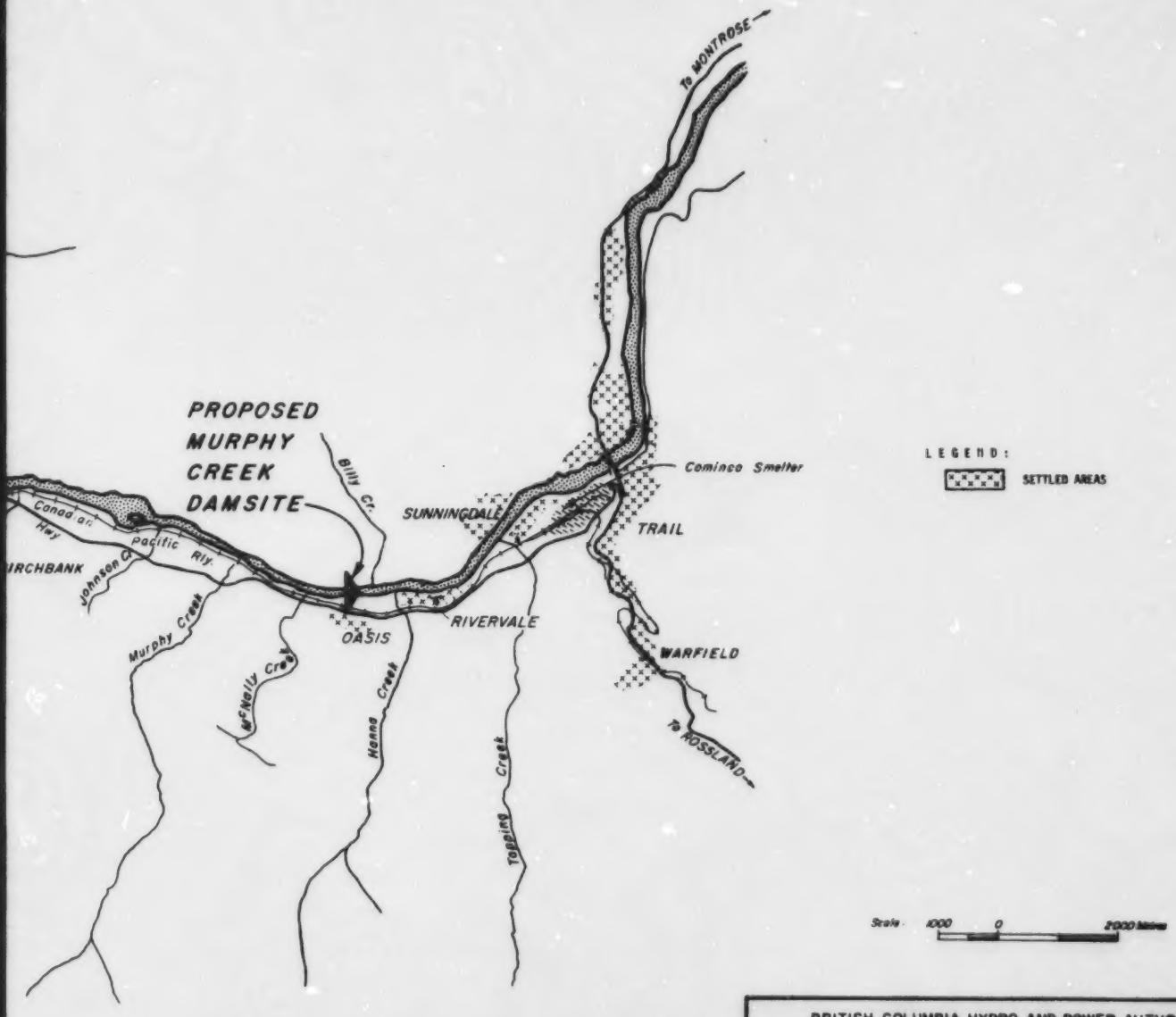
KILOMETRES
NEAR TRAIL B.C.

LEGEND

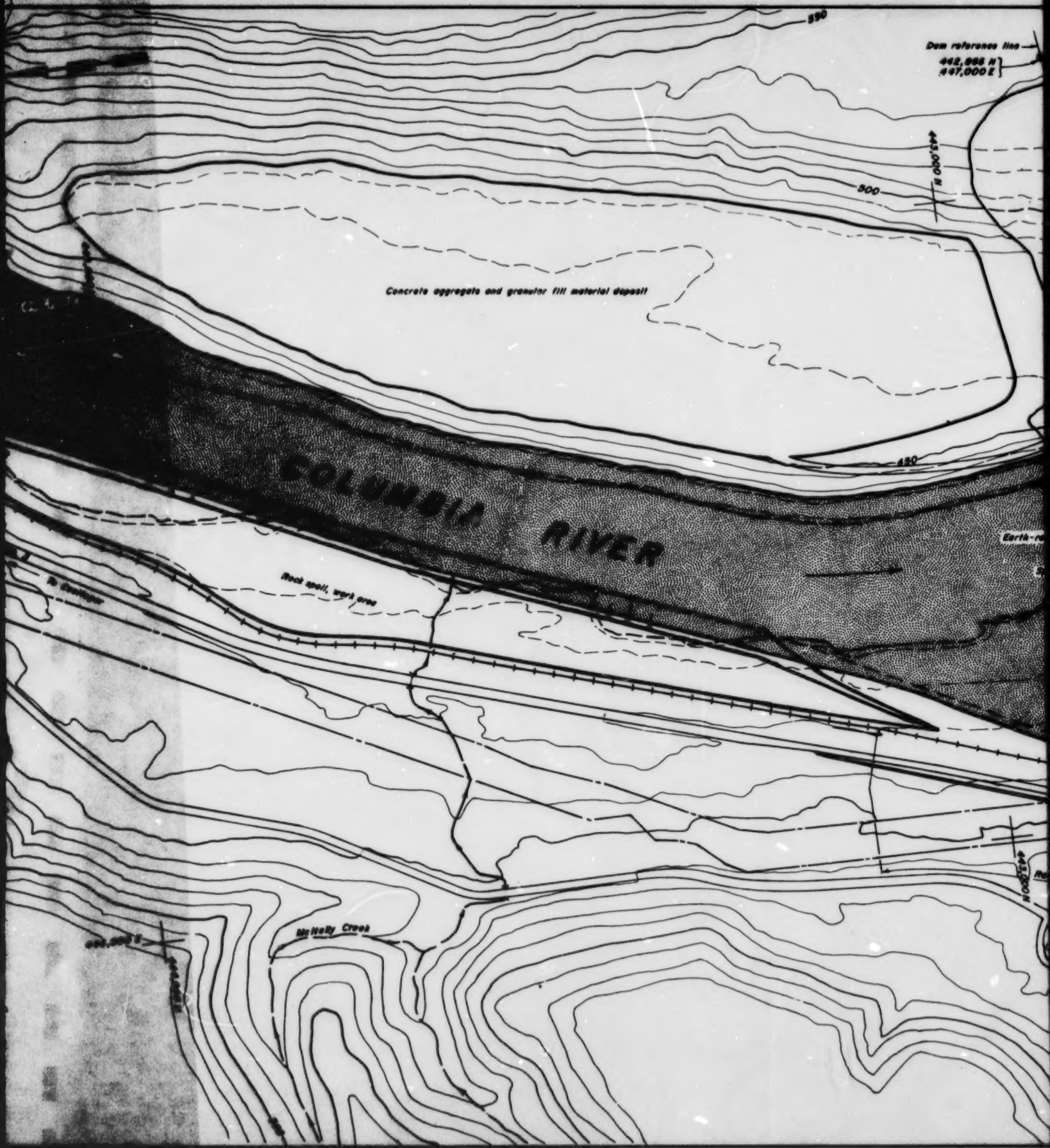
- Existing
- Proposed
- City or town

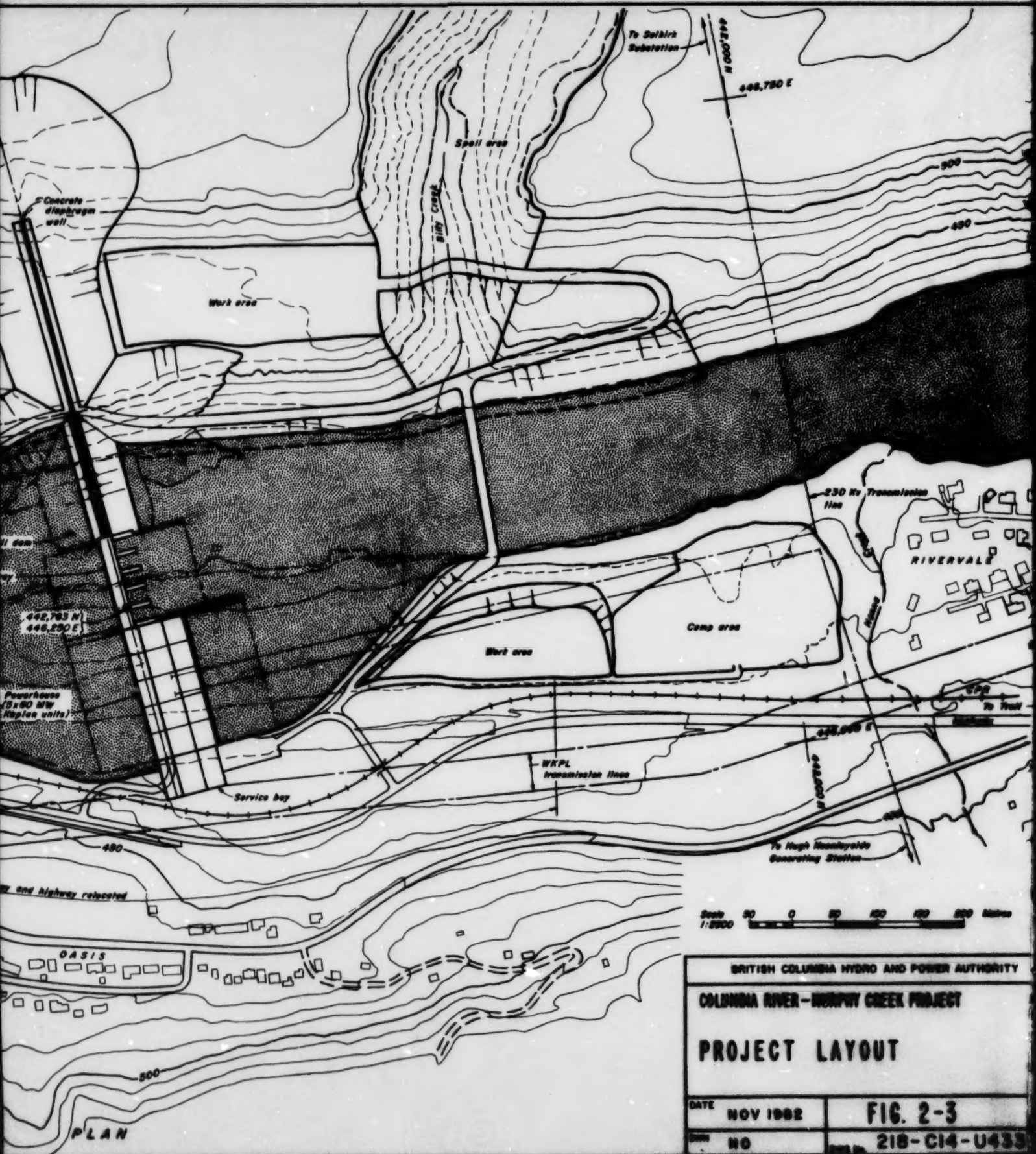
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY	
COLUMBIA RIVER - MURPHY CREEK PROJECT	
COLUMBIA & KOOTENAY RIVER PROFILE	
DATE NOV 1982	FIG. 2-1 R
DWN MWB	DWG No. 218-C14-D434


N
McPhee Cr.
KOOTENAY R.
To NELSON, NAKUSP
BRILLIANT DAM
Hwy. No. 3A
OOTISCHENIA
To SALMO
Airfield
BRILLIANT
SELKIRK COLLEGE
EAST RASPBERRY
PASS CREEK REGIONAL PARK
Norns Cr.
SOUTH CASTLEGAR
BLUEBERRY CREEK
Champion Cr.
Jordan Cr.
NORTH CASTLEGAR
RASPBERRY
Ferry (WSC Gauge)
Blueberry Creek
FAIRVIEW
COLUMBIA R.
ROBSON
China Creek
CHINA CREEK
GENELLE
B C Timber Pulp and Saw Mill
Sullivan Creek
HUGH KEENLEYSIDE DAM
Hwy. No. 3
ARROW LAKES RESERVOIR
To SYRINGA Cr.
To GRAND FORKS



BRITISH COLUMBIA HYDRO AND POWER AUTHORITY	
COLUMBIA RIVER - MURPHY CREEK PROJECT	
LOCATION MAP	
DATE NOV 1982	FIG. 2-2 R
DWN MWB	DWG No. 218-C14-D419


590
Dam reference line
462,000 N
497,000 E
445,000 N
500
Concrete aggregate and granular fill material deposit
430
COLUMBIA RIVER
Earth-r
Rock spoil, work area
McNally Creek

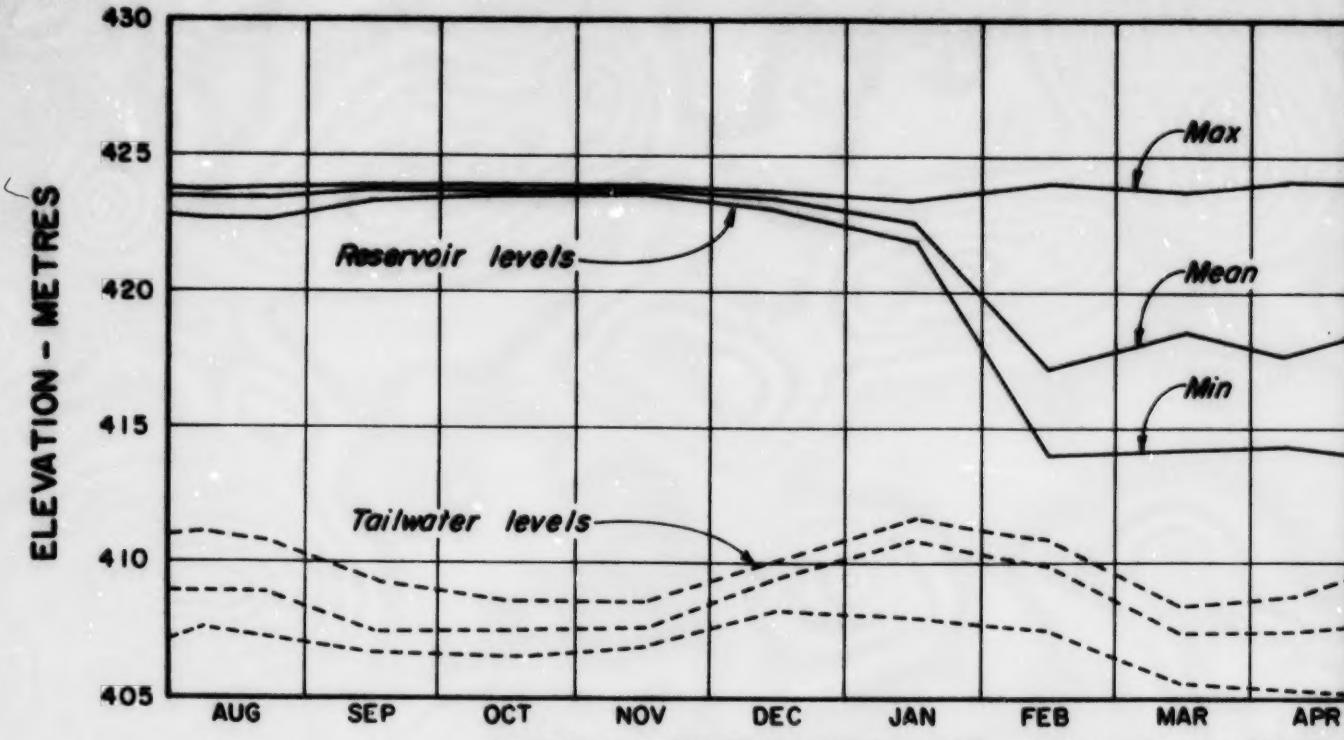


BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

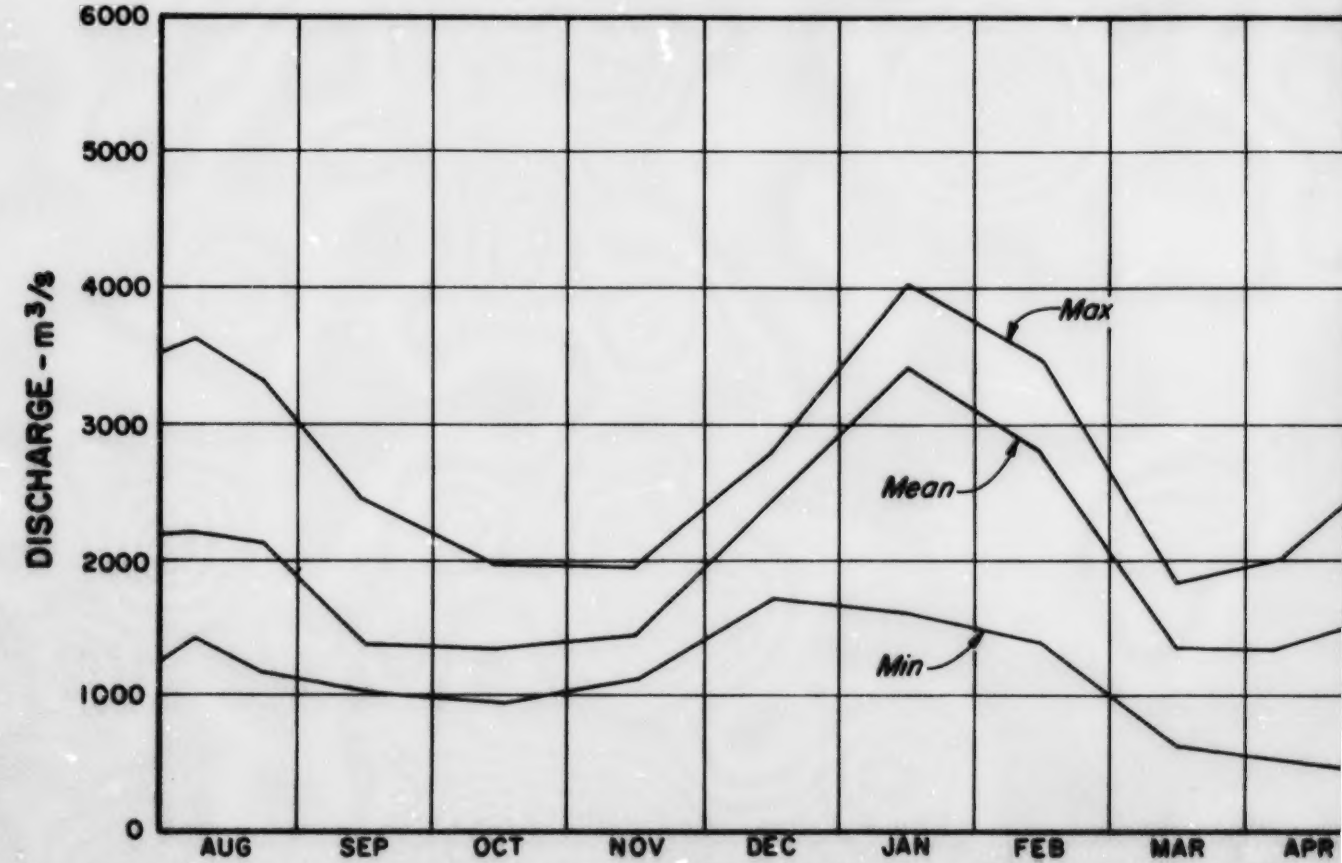
COLUMBIA RIVER – MURPHY CREEK PROJECT

PROJECT LAYOUT

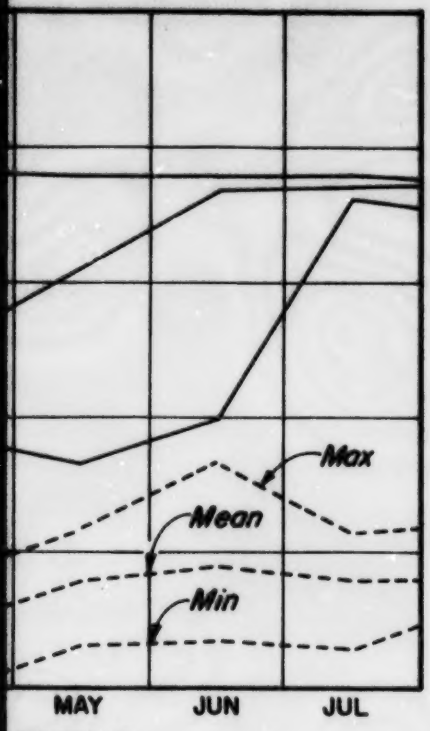
DATE NOV 1982	FIG. 2-3
DRWN NO	DRWG No. 218-C14-U433



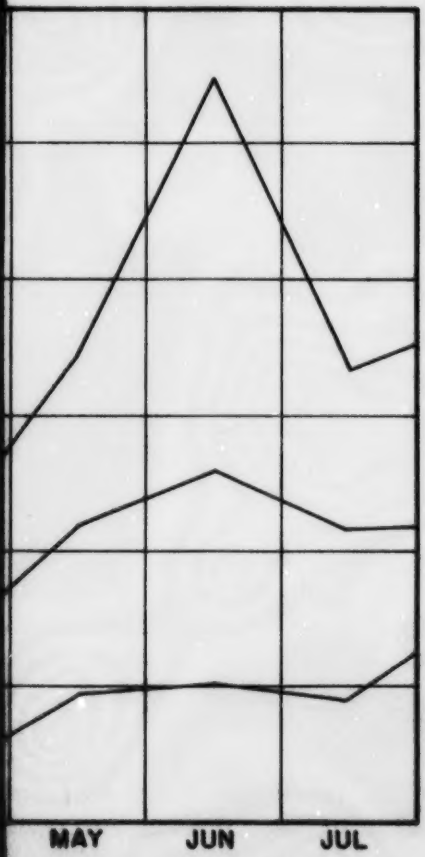
MURPHY CREEK RESERVOIR AND TAILWATER



MURPHY CREEK TOTAL DISCHARGE



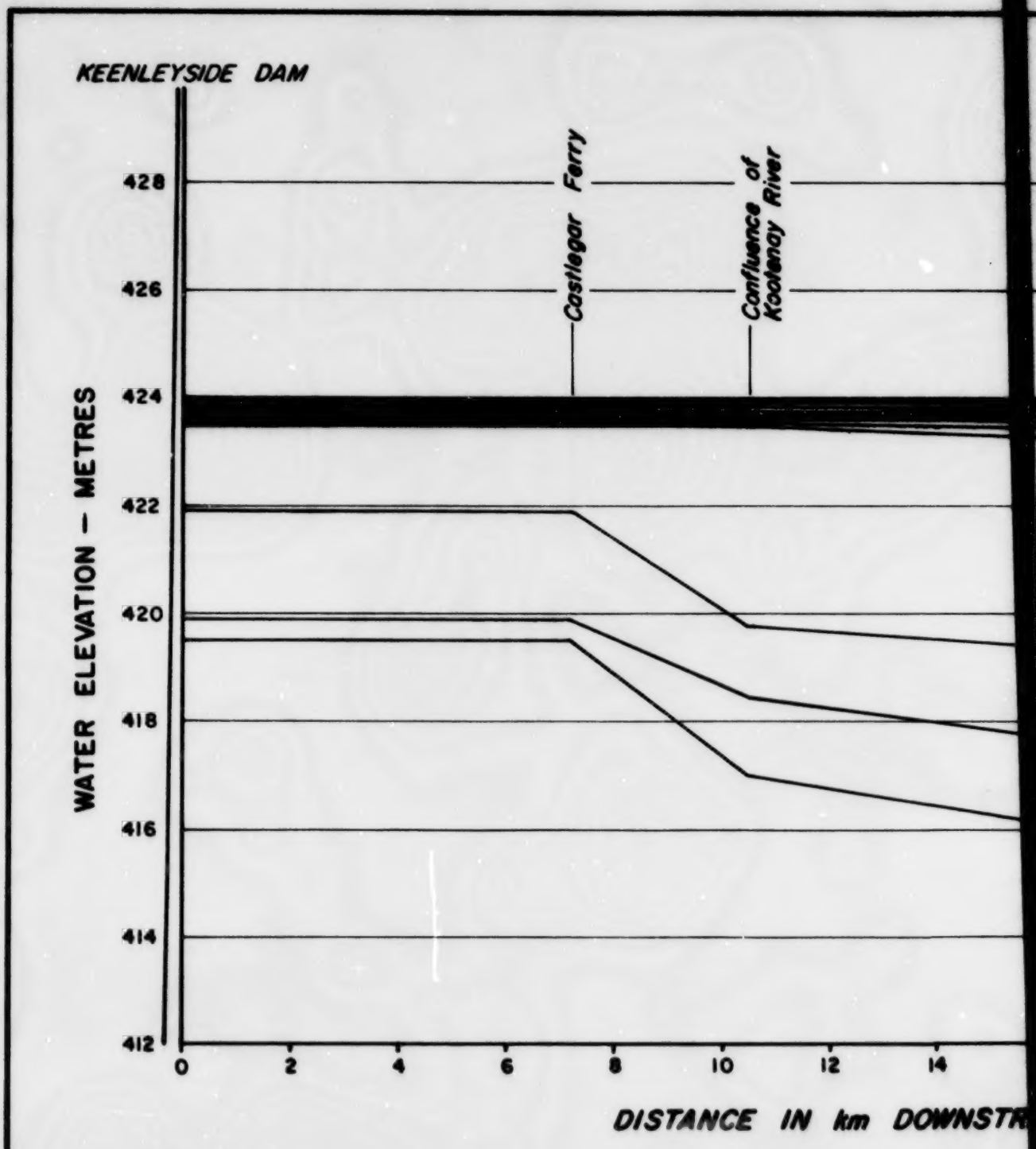
EVELS



N O T E:

RESERVOIR LEVELS SHOWN ARE AT THE DAM AND ARE BASED ON A MAXIMUM OPERATING LEVEL OF 424 m AT CASTLEGAR FERRY WATER LEVEL GAUGE

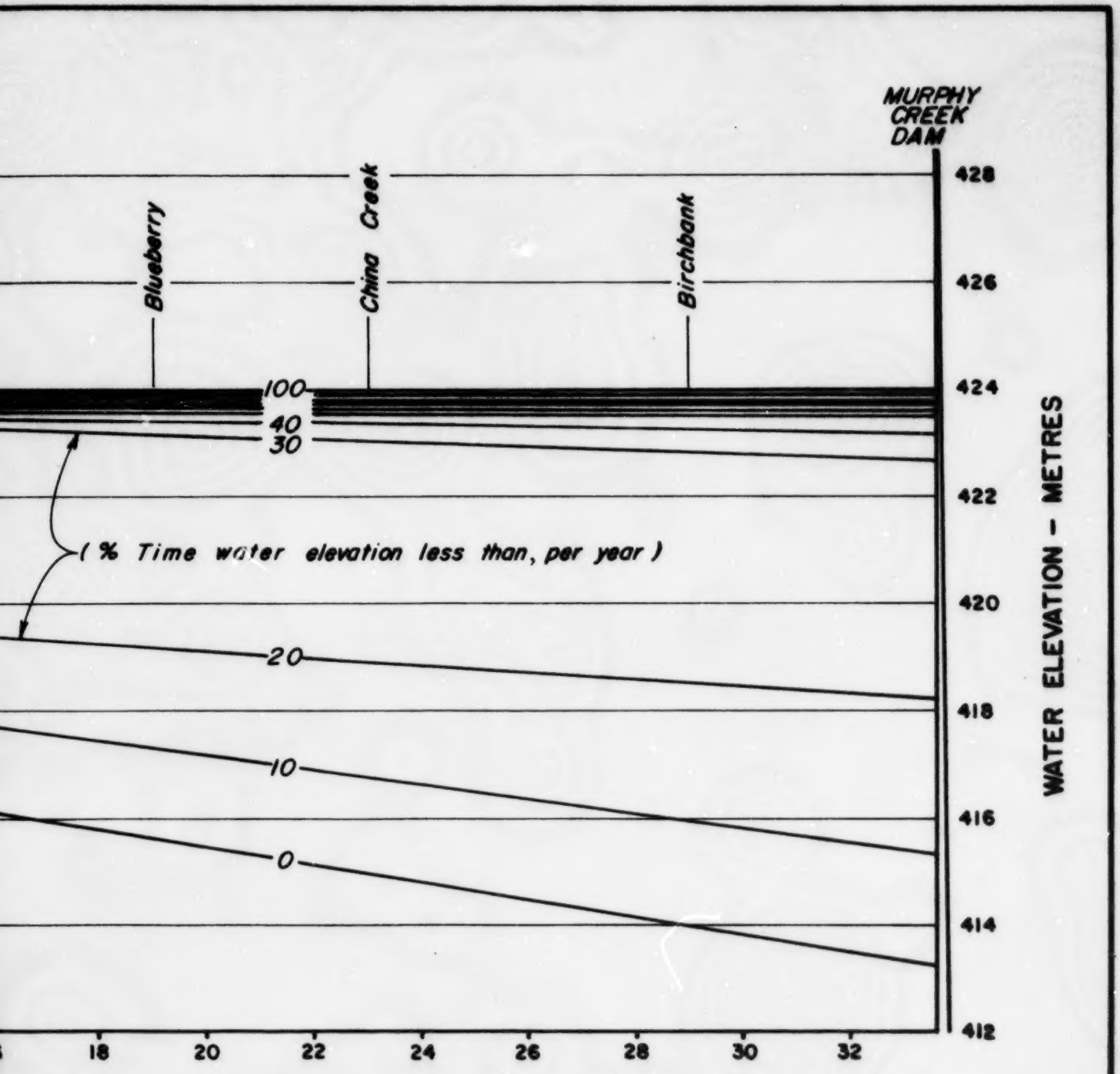
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY	
COLUMBIA RIVER—MURPHY CREEK PROJECT **WATER LEVELS & DISCHARGE HYDROGRAPHS OPERATING REGIME 1**	
DATE NOV 1982	FIG. 3-1
DWN FL	DWG. No. 218-C14-B424



NOTES:

1. RESERVOIR LEVELS SHOWN ARE BASED ON A MAXIMUM OPERATING LEVEL OF El 424 AT CASTLEGAR FERRY WATER LEVEL GAUGE.

2. RESERVOIR LEVEL DATA IS BASED ON 35 YEAR MONTHLY FLOW SIMULATION.



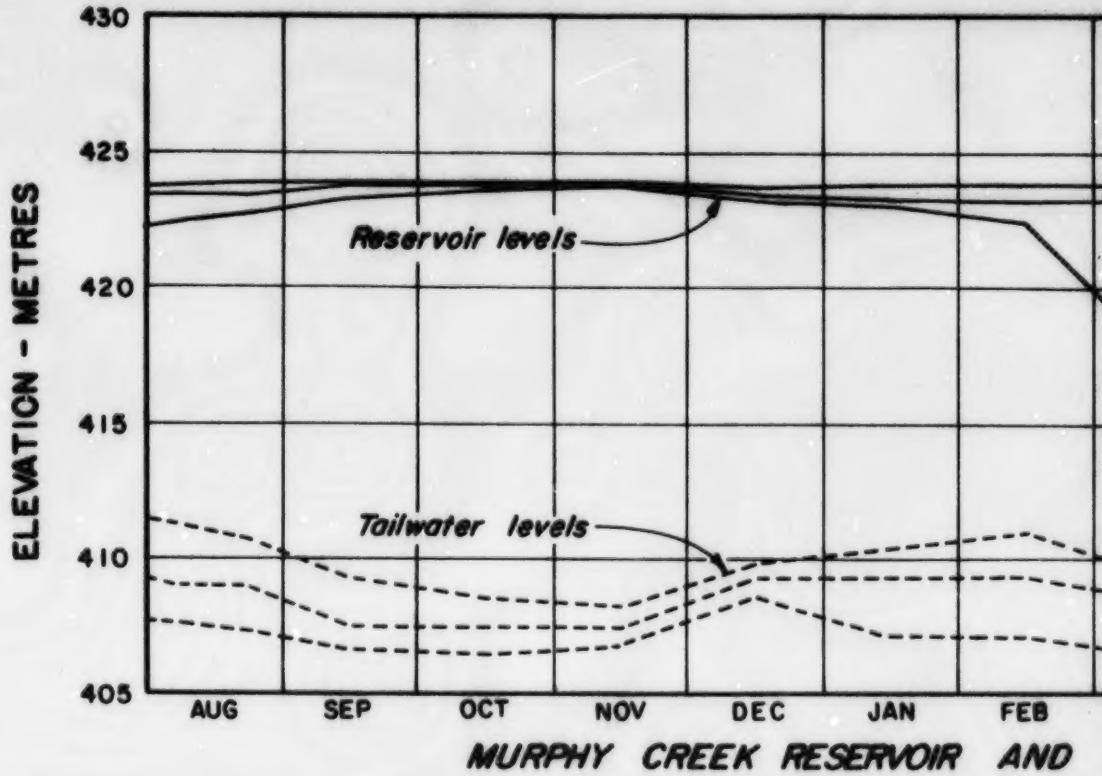
AM FROM KEENLEYSIDE DAM

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

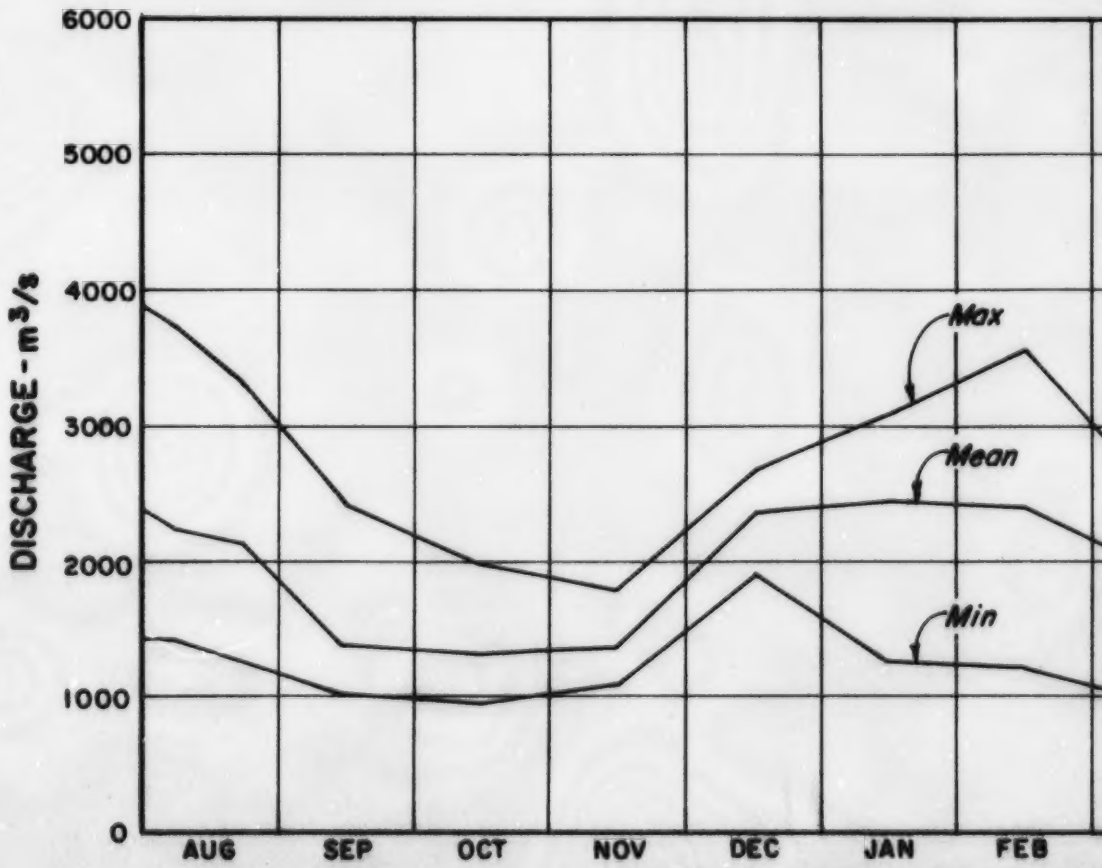
COLUMBIA RIVER - MURPHY CREEK PROJECT

RESERVOIR LEVELS
OPERATING REGIME 1

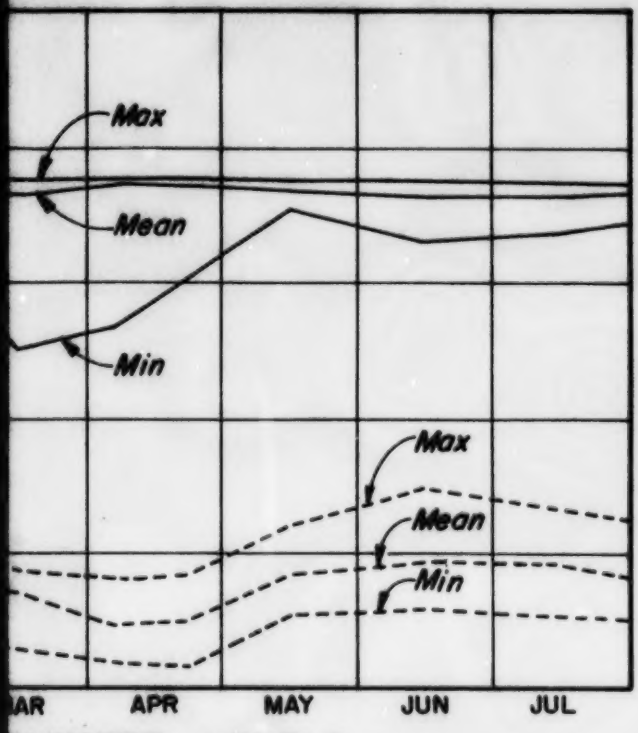
DATE NOV 1982	FIG. 3-2
DWN FL	DWG. No. 218-C14-B425



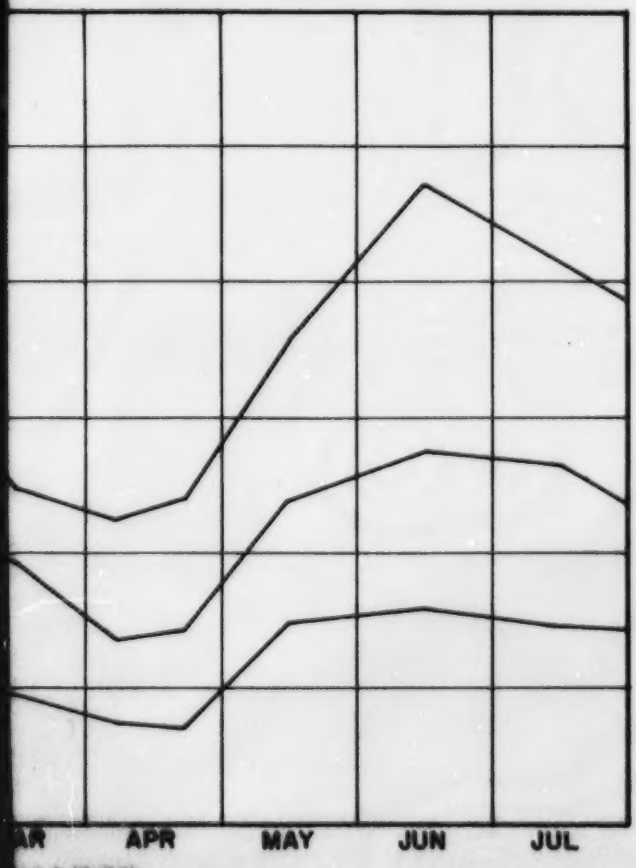
MURPHY CREEK RESERVOIR AND



MURPHY CREEK TOTAL D



LWATER LEVELS



HARGE

N O T E:

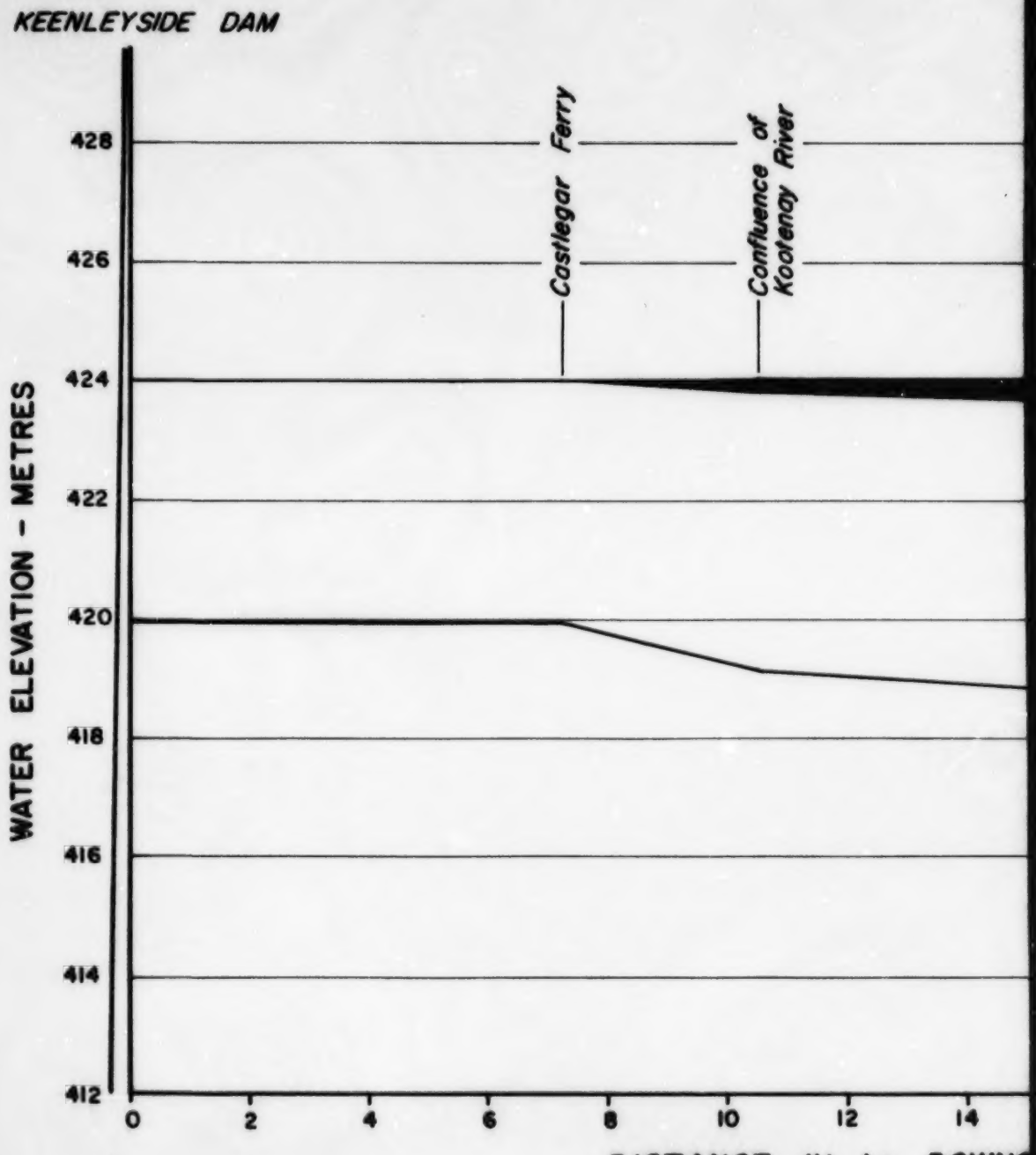
RESERVOIR LEVELS SHOWN ARE AT THE DAM AND ARE BASED ON A MAXIMUM OPERATING LEVEL OF El 424 AT CASTLEGAR FERRY WATER LEVEL GAUGE

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

COLUMBIA RIVER – MURPHY CREEK PROJECT

WATER LEVELS AND DISCHARGE HYDROGRAPHS OPERATING REGIME 2

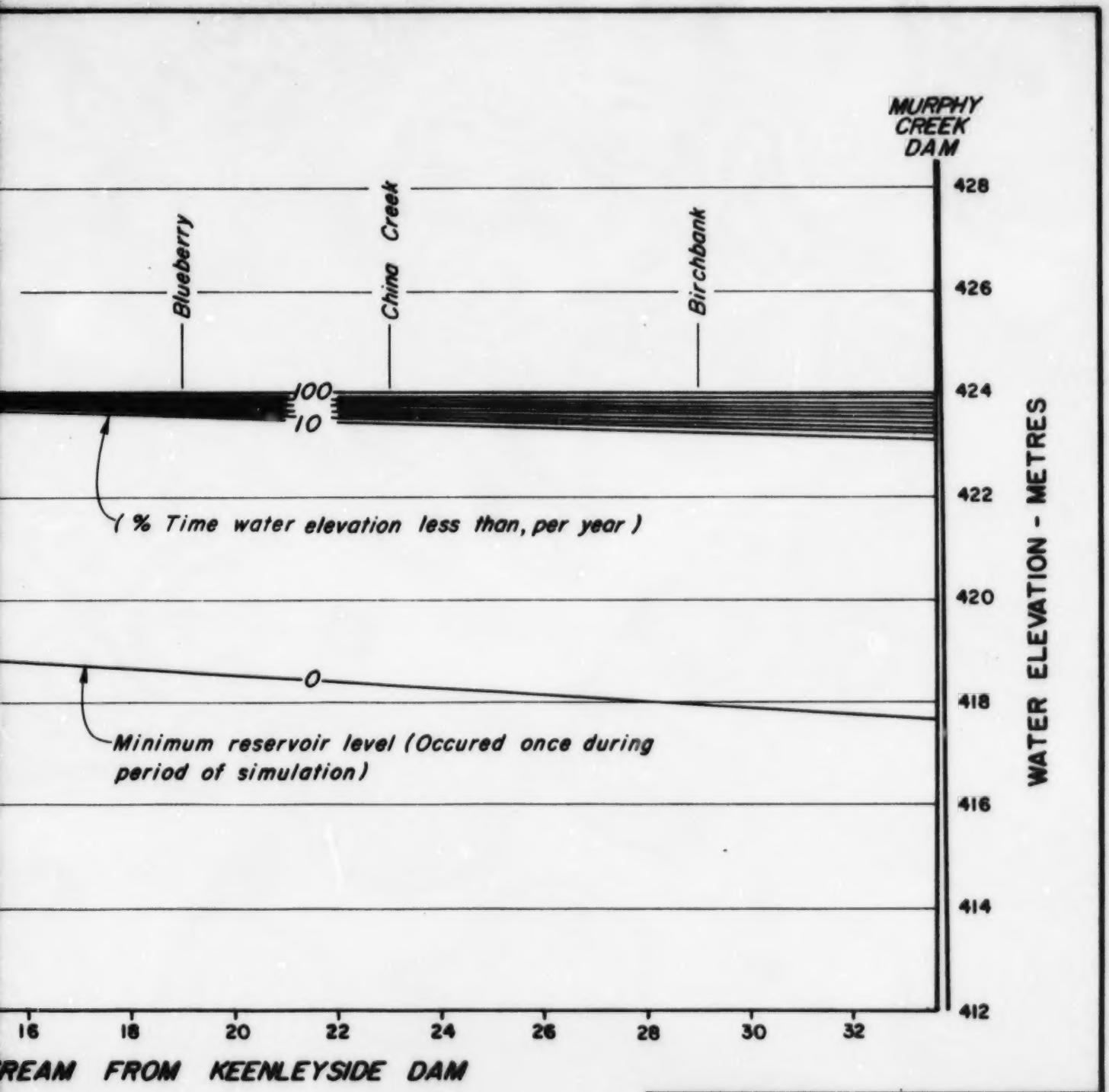
DATE NOV 1982	FIG. 3-3
DWN FL	DRG. No. 218-C14-B428



NOTES:

1. RESERVOIR LEVELS SHOWN ARE BASED ON A MAXIMUM OPERATING LEVEL OF El 424 AT CASTLEGAR FERRY WATER LEVEL GAUGE.

2. RESERVOIR LEVEL DATA IS BASED ON 35 YEAR MONTHLY FLOW SIMULATION.

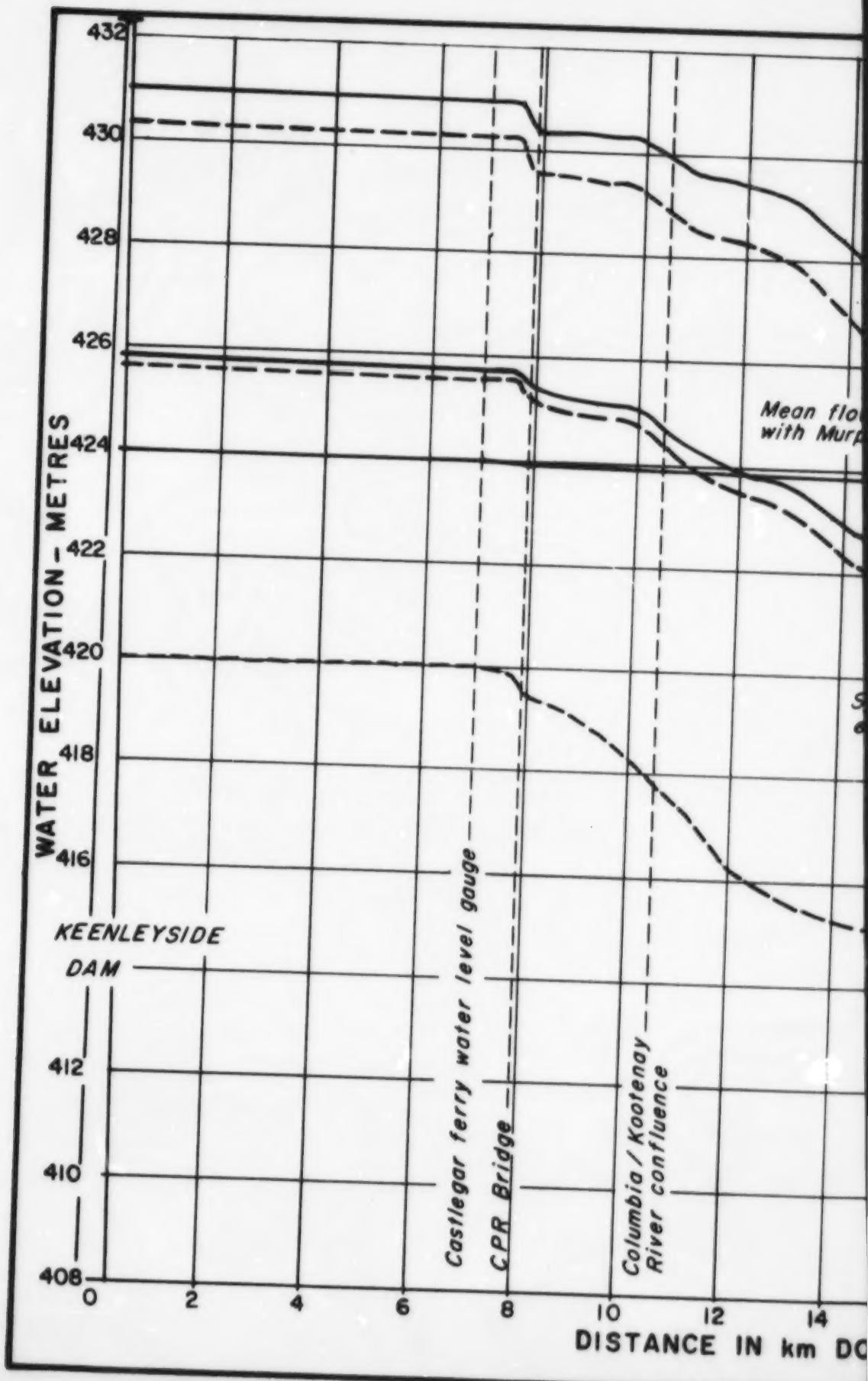


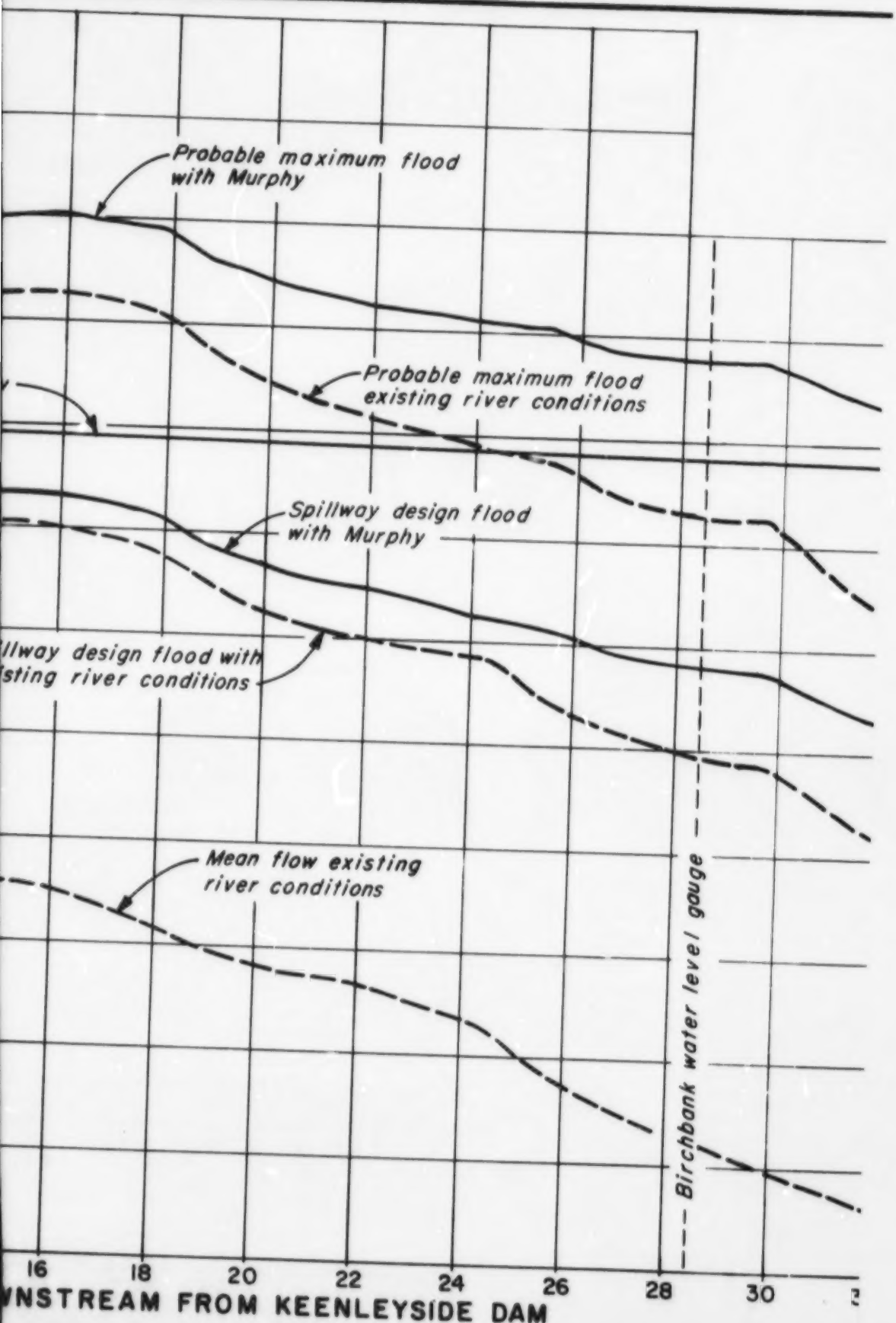
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

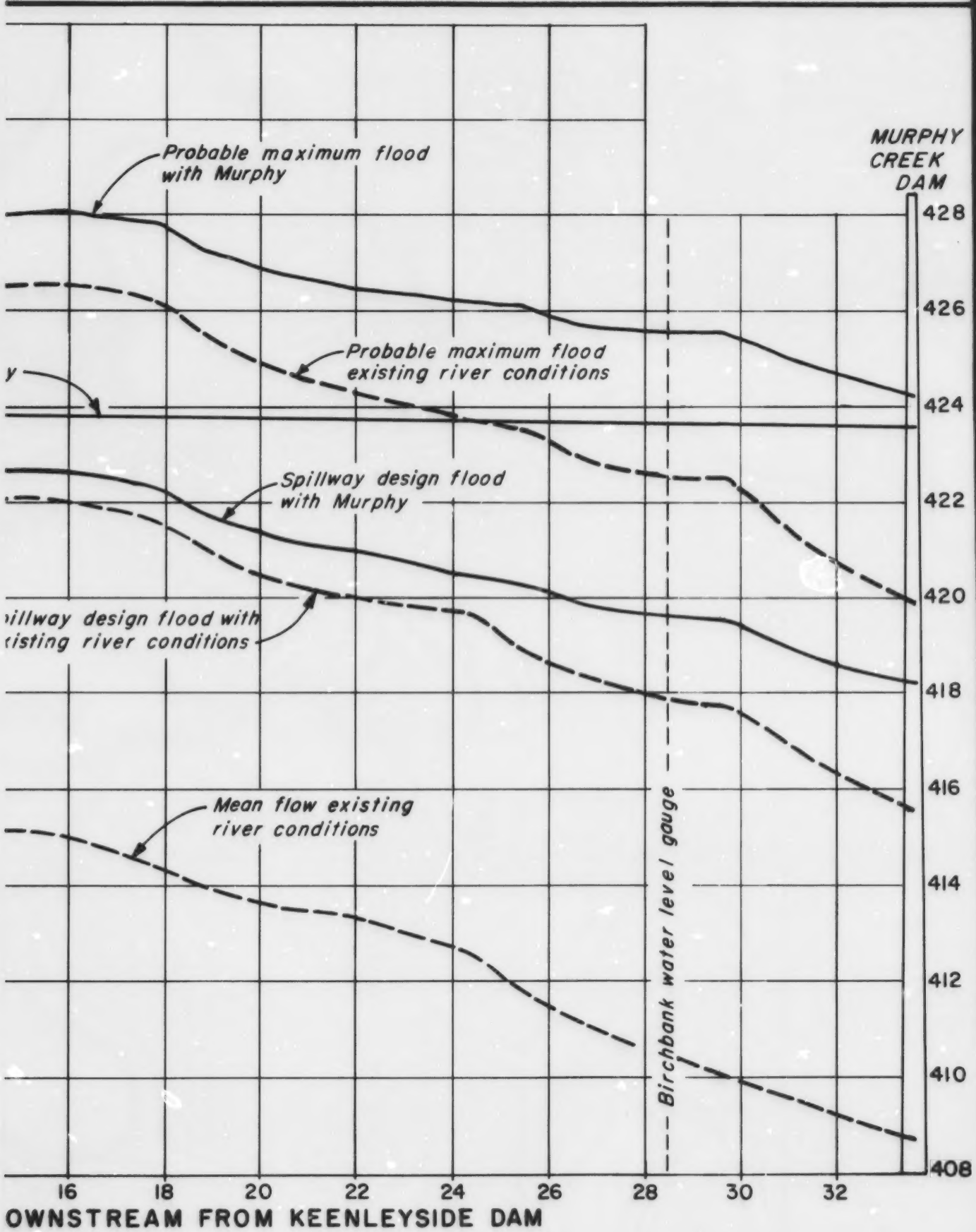
COLUMBIA RIVER – MURPHY CREEK PROJECT

RESERVOIR LEVELS
OPERATING REGIME 2

DATE NOV 1982	FIG. 3-4
DWN FL	DWG. No. 218-C14-B427


WATER ELEVATION - METRES
432
430
428
426
424
422
420
418
416
412
410
408
KEENLEYSIDE DAM
Castlegar ferry water level gauge
CPR Bridge
Columbia / Kootenay River confluence
Mean flo
with Murp
0
2
4
6
8
10
12
14
DISTANCE IN km DO


Probable maximum flood with Murphy
Probable maximum flood existing river conditions
Spillway design flood with Murphy
llway design flood with
sting river conditions
Mean flow existing river conditions
Birchbank water level gauge
16
18
20
22
24
26
28
30
VNSTREAM FROM KEENLEYSIDE DAM


MURPHY CREEK DAM
Probable maximum flood with Murphy
Probable maximum flood existing river conditions
Spillway design flood with Murphy
Mean flow existing river conditions
Birchbank water level gauge
428
426
424
422
420
418
416
414
412
410
408
16
18
20
22
24
26
28
30
32
OWNSTREAM FROM KEENLEYSIDE DAM

N O T E S:

1. FLOW SPLITS AT DIFFERENT FLOWS FOR THE COLUMBIA/KOOTENAY RIVERS ARE:

   PROBABLE MAXIMUM FLOOD-69/31
   SPILLWAY DESIGN FLOOD -55/45
   MEAN FLOW -56/44

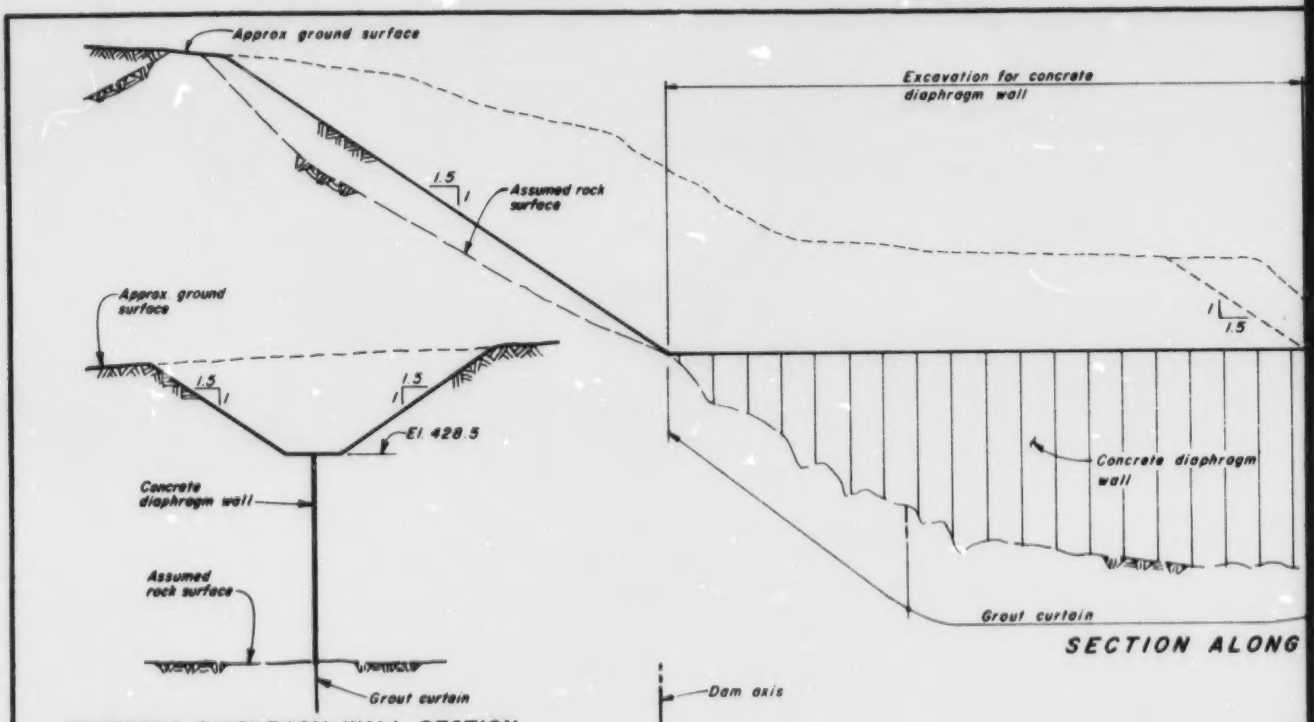
2. WATER ELEVATIONS WERE DERIVED FROM A COMPUTER BACKWATER SIMULATION.

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

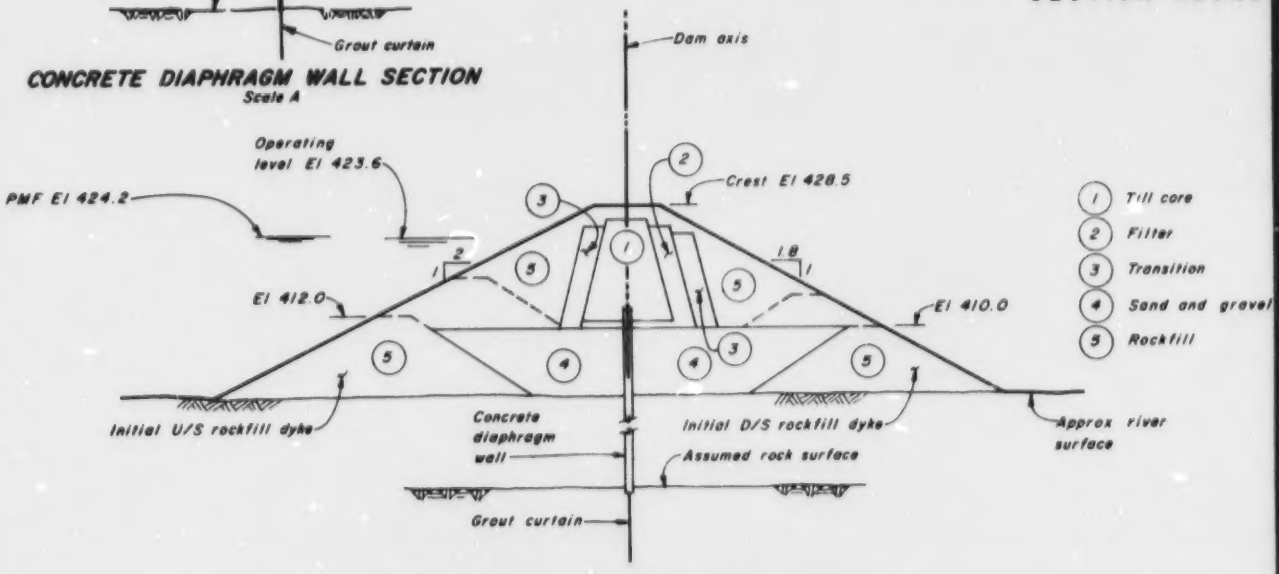
COLUMBIA RIVER - MURPHY CREEK PROJECT

BACKWATER PROFILES

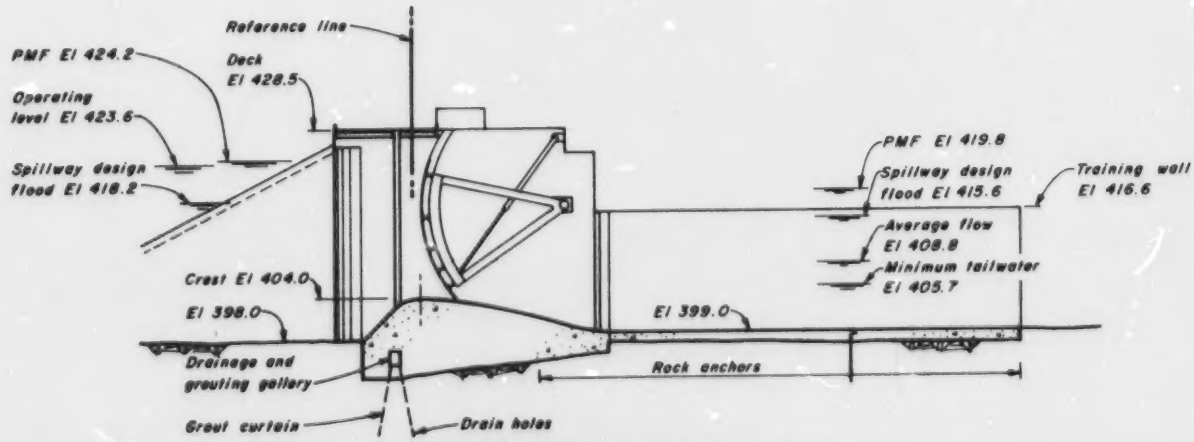
DATE NOV 1982	FIG. 3-5	R
DWN AKW	DWG No. 218-C14-C421	



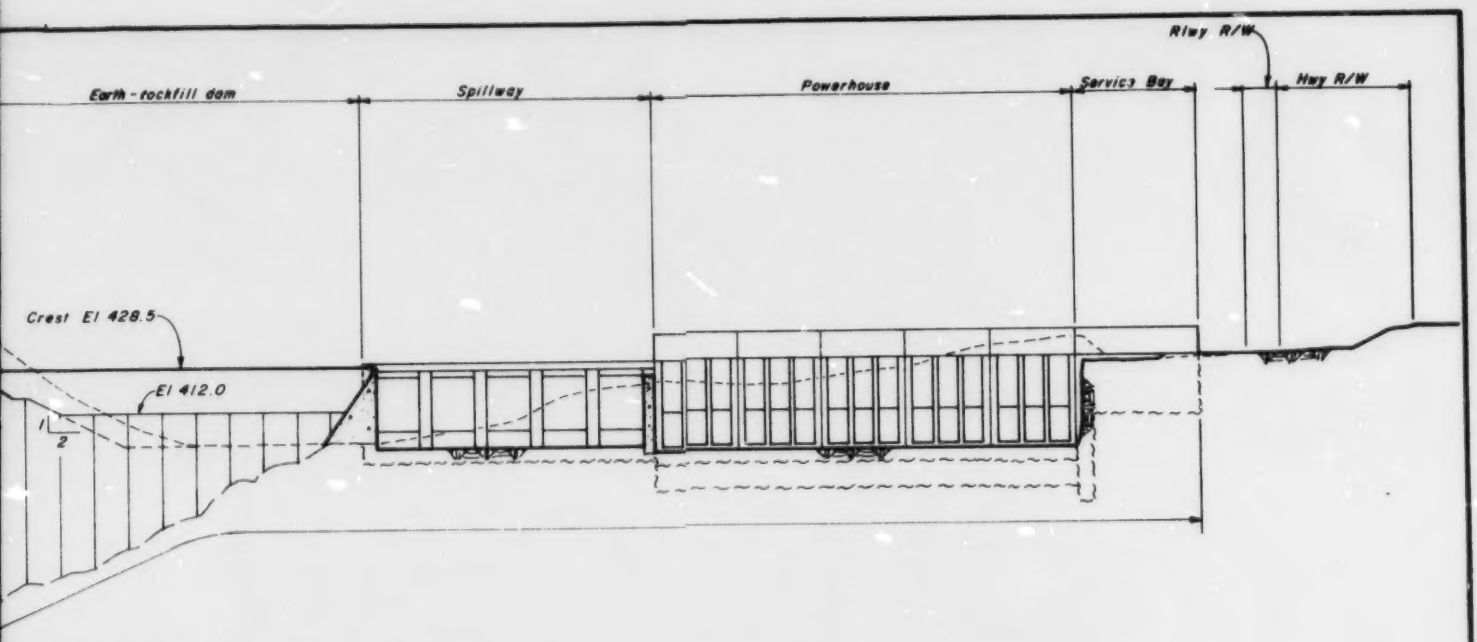
CONCRETE DIAPHRAGM WALL SECTION
Scale A

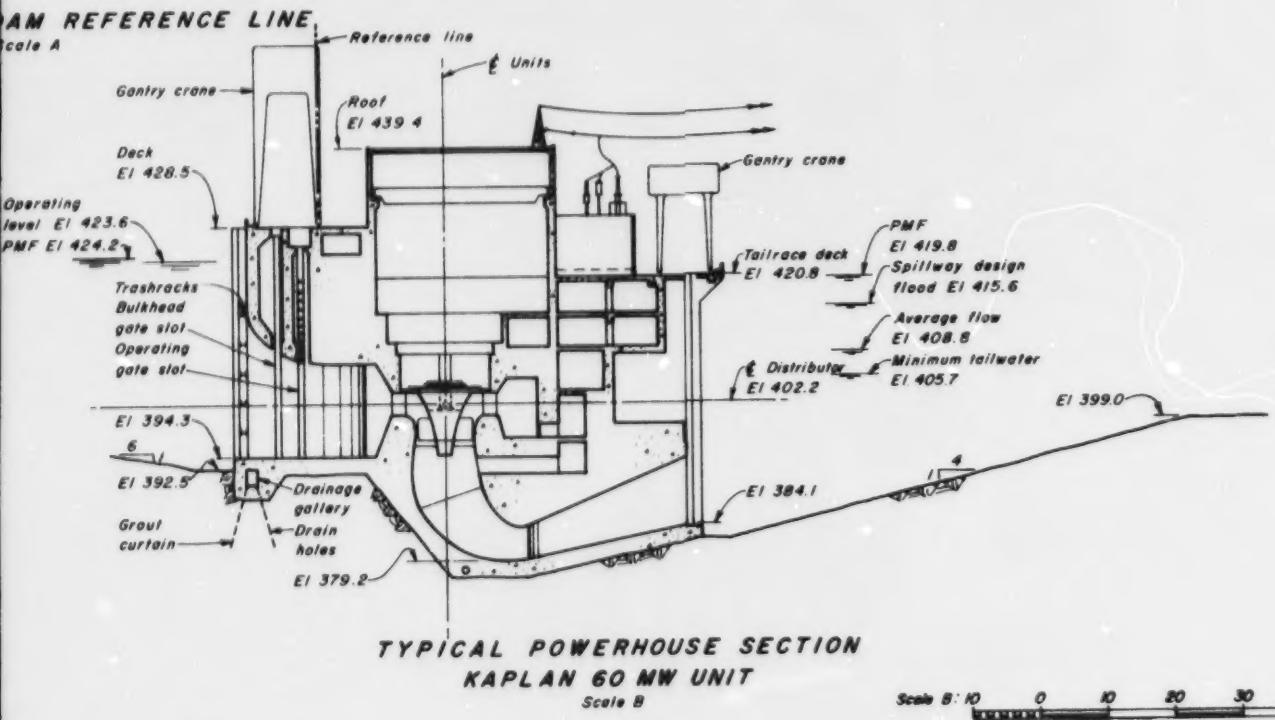


TYPICAL EARTH-ROCKFILL DAM SECTION
Scale B



TYPICAL SPILLWAY SECTION
Scale B





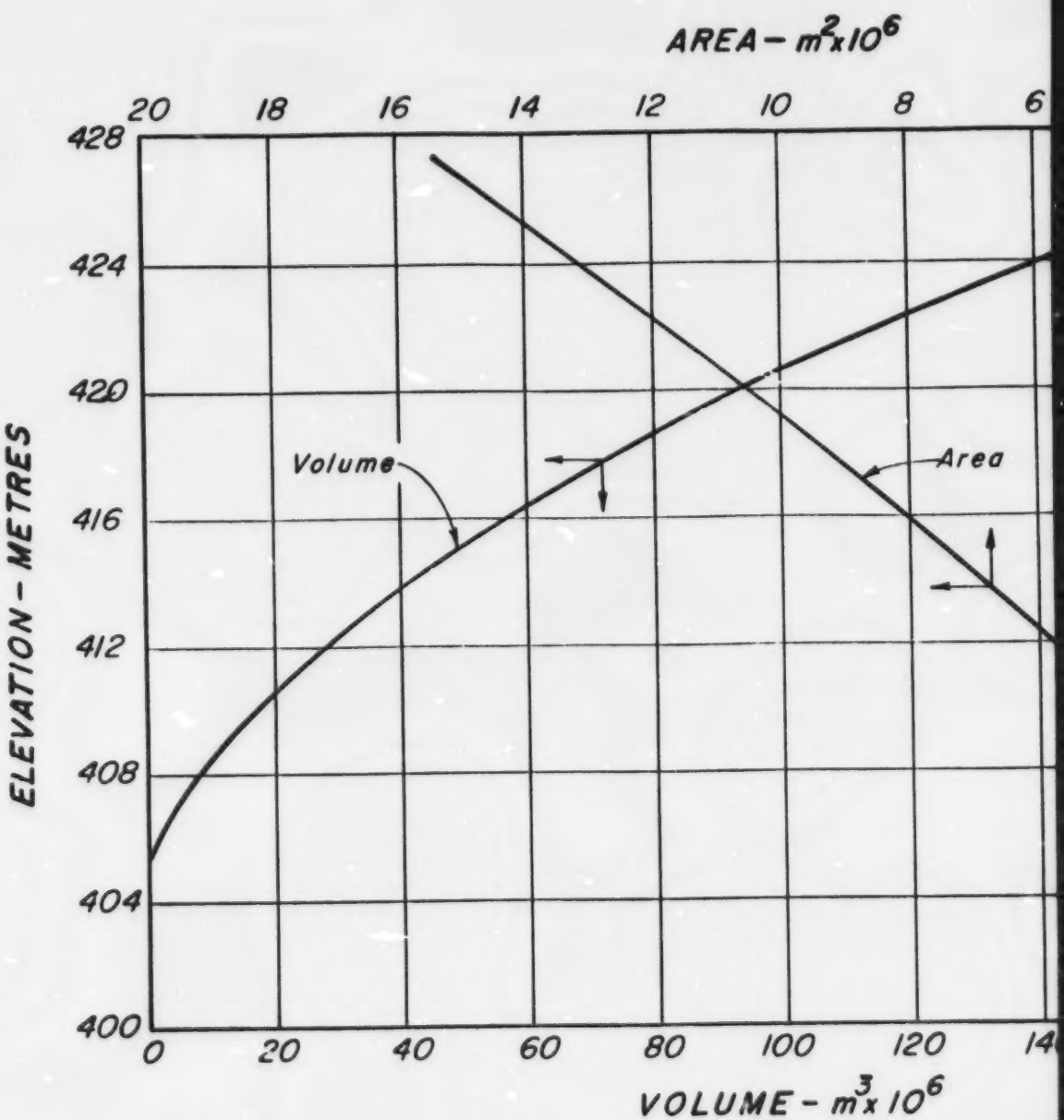
TYPICAL POWERHOUSE SECTION
KAPLAN 60 MW UNIT
Scale B

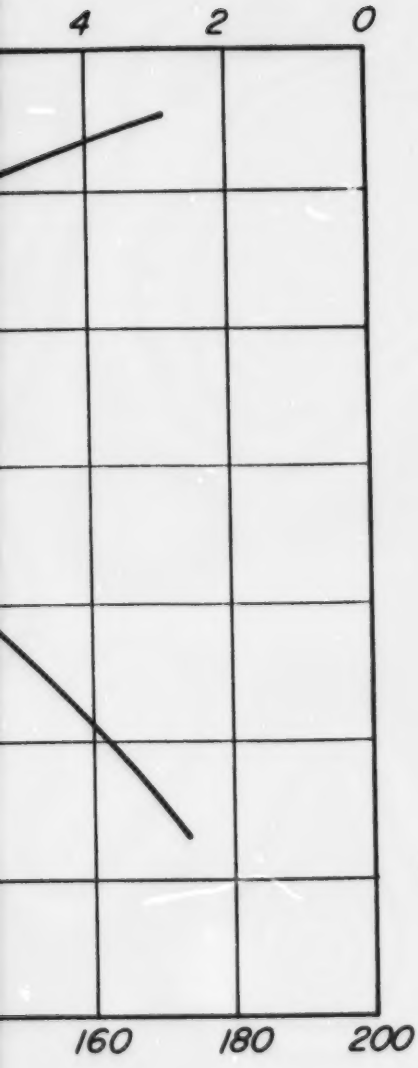
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

COLUMBIA RIVER - MURPHY CREEK PROJECT

PROJECT SECTIONS

DATE	NOV 1982	FIG. 4-1	R
DWN	M W B	DWG No.	218 - C14 - D422


AREA - $m^2 \times 10^6$
20
18
16
14
12
10
8
6
428
424
420
416
412
408
404
400
ELEVATION - METRES
Volume
Area
0
20
40
60
80
100
120
VOLUME - $m^3 \times 10^6$

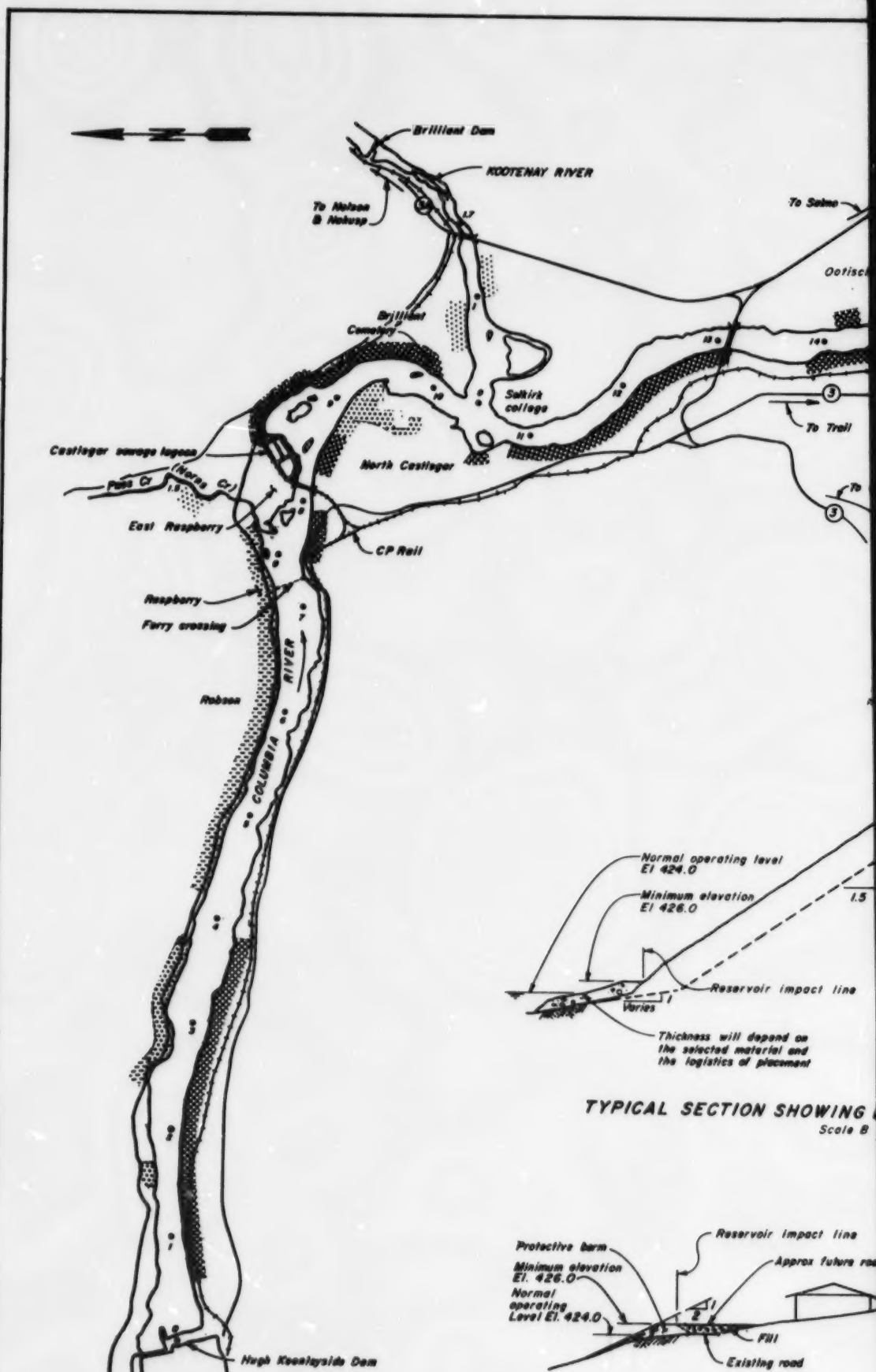


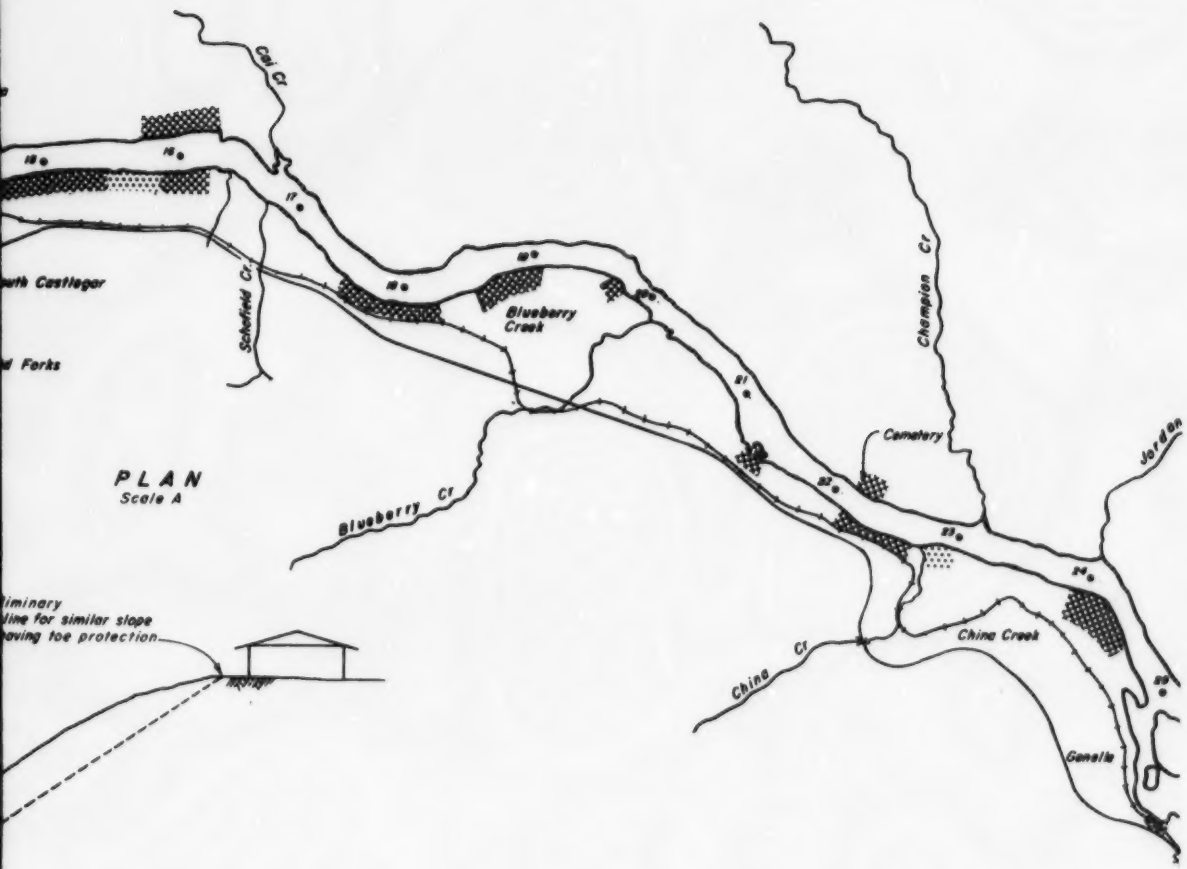
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

COLUMBIA RIVER - MURPHY CREEK PROJECT

RESERVOIR AREA AND VOLUME CURVES

DATE NOV 1982	FIG 5-1
DWN N.O.	DWG. No 218-C18-B428

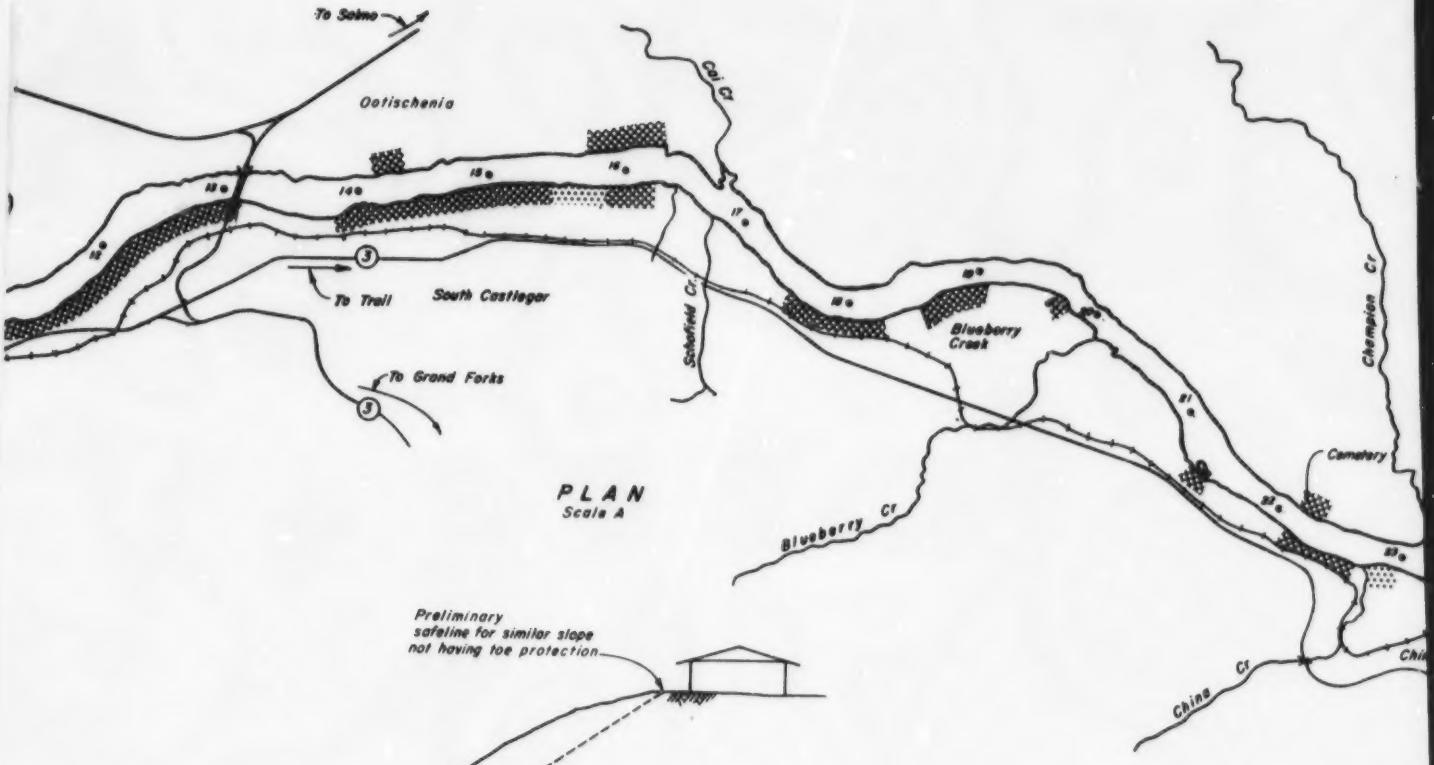

Brilliant Dam
KOOTENAY RIVER
To Nelson & Nakusp
To Salmo
Ootisc
Brilliant Cemetery
Selkirk college
To Trail
Castlegar sewage lagoon
North Castlegar
Pass Cr
(Korea Cr)
East Raspberry
CP Rail
Raspberry
Ferry crossing
COLUMBIA RIVER
Robson
Hugh Keenleyside Dam
Normal operating level El 424.0
Minimum elevation El 426.0
1.5
Reservoir impact line
Varies
Thickness will depend on the selected material and the logistics of placement
TYPICAL SECTION SHOWING
Scale 8
Protective berm
Minimum elevation El. 426.0
Normal operating Level El. 424.0
Reservoir impact line
Approx future ro
Fill
Existing road
TYPICAL SECTION SHOWING PROTECTIV
Scale 8



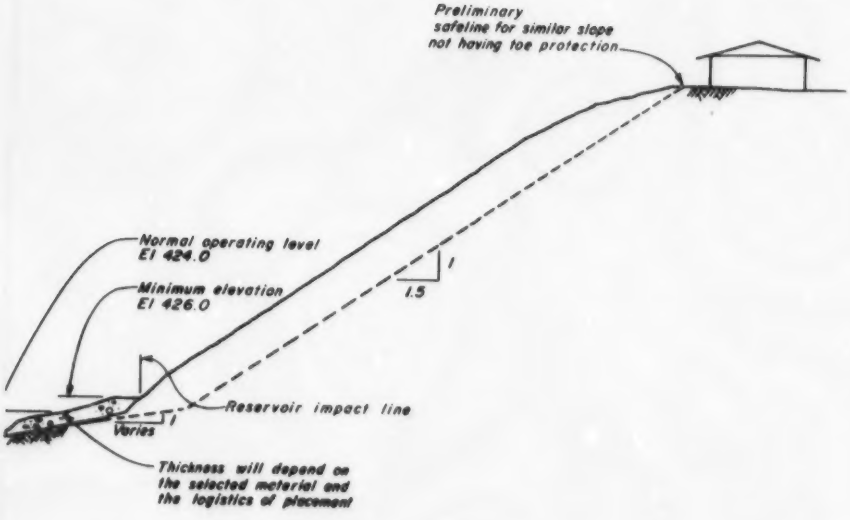
NK TOE PROTECTION

ERM AND FILL

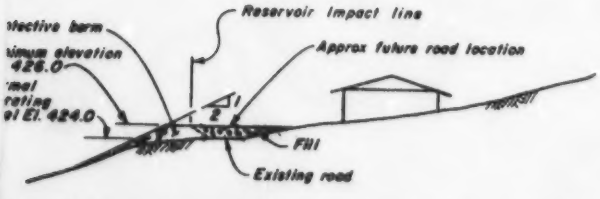
RIVER



PLAN
Scale A


Preliminary safeline for similar slope not having toe protection
Normal operating level El 424.0
Minimum elevation El 426.0
1
1.5
Reservoir impact line
Varies
Thickness will depend on the selected material and the logistics of placement

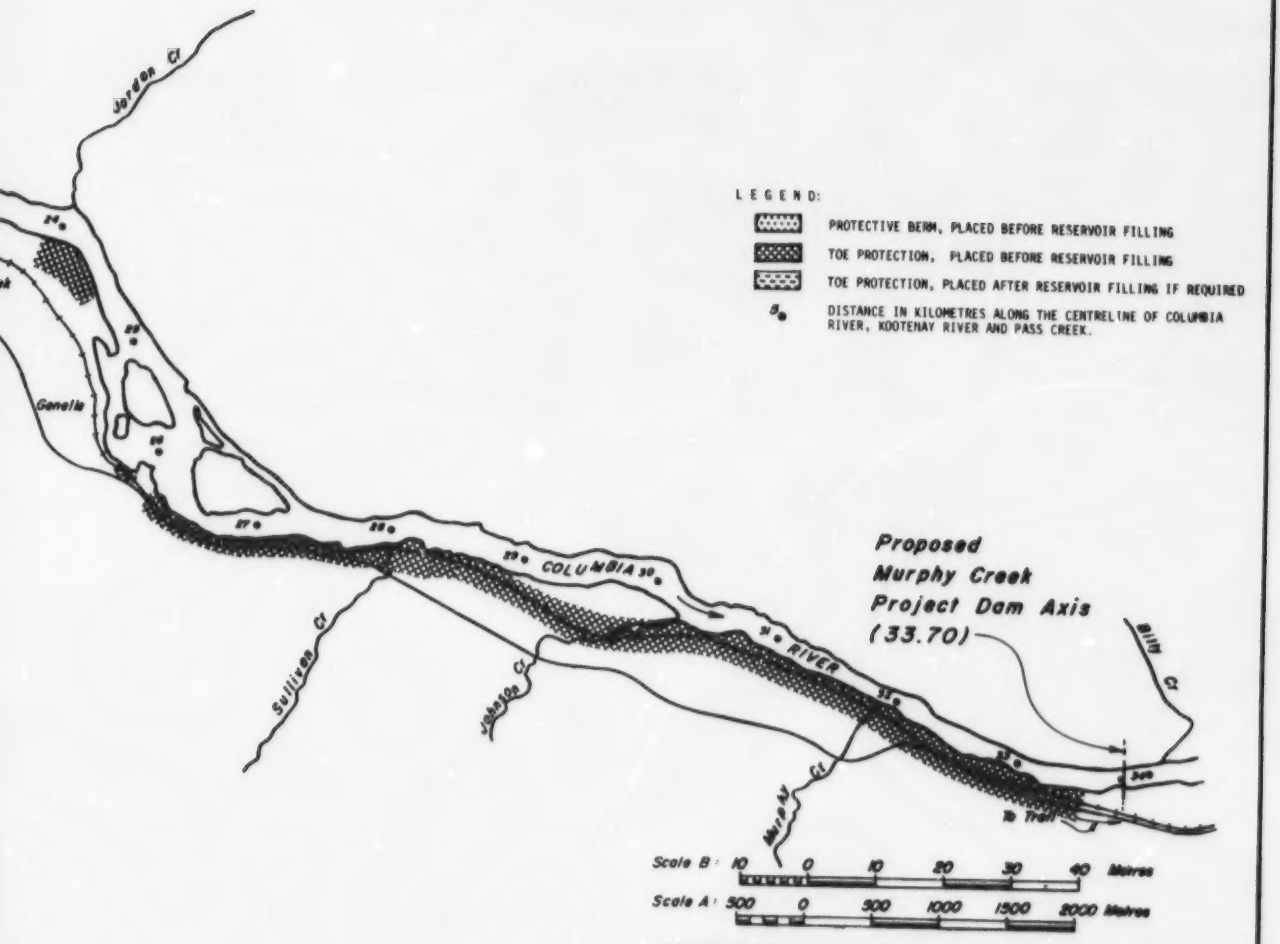
TYPICAL SECTION SHOWING BANK TOE PROTECTION
Scale B



AL SECTION SHOWING PROTECTIVE BERM AND FILL
Scale B

NOTES:

1. C.P. RAIL TRACK WOULD BE RAISED, RELOCATED OR PROTECTED AS REQUIRED.

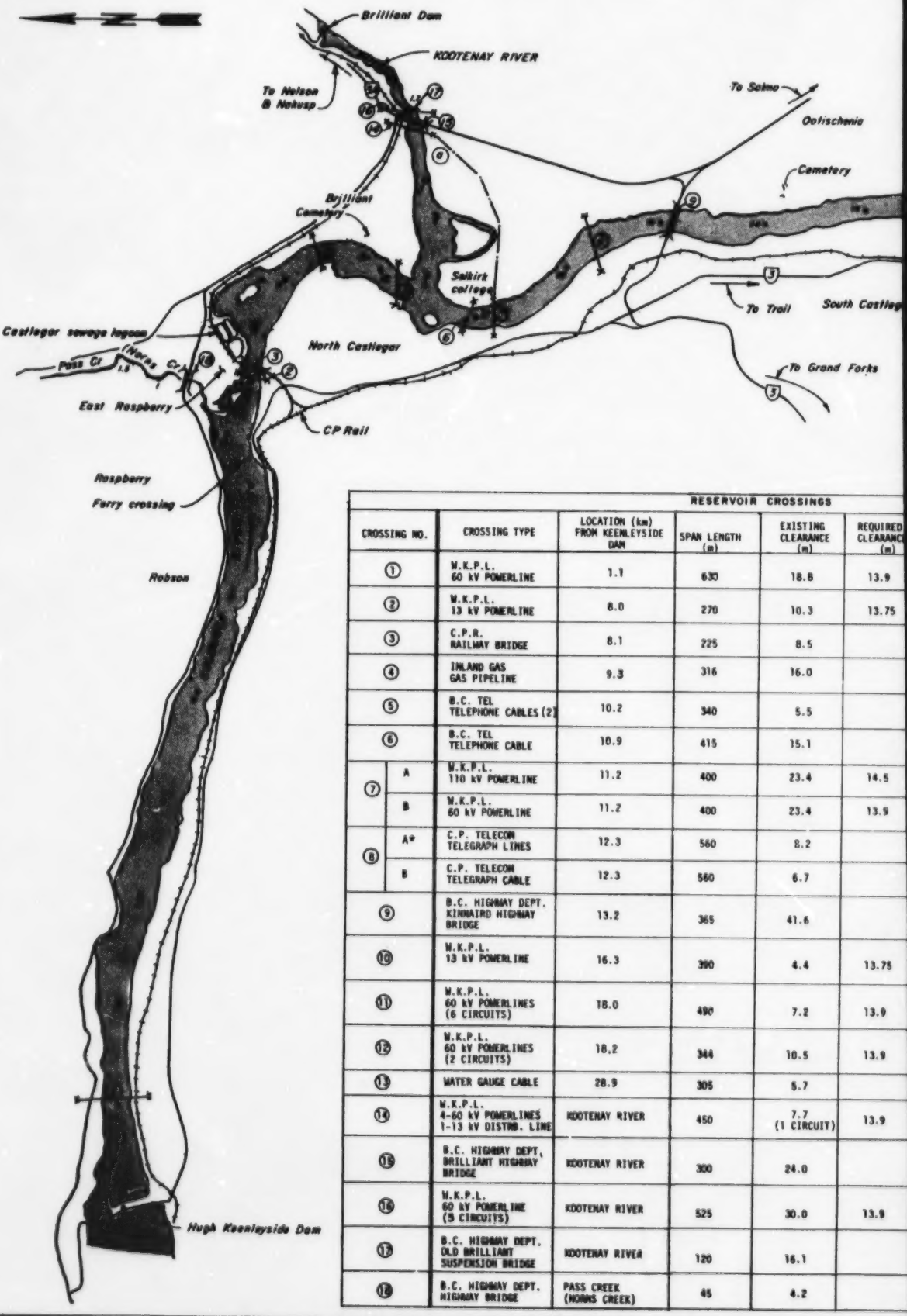


BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

COLUMBIA RIVER - MURPHY CREEK PROJECT

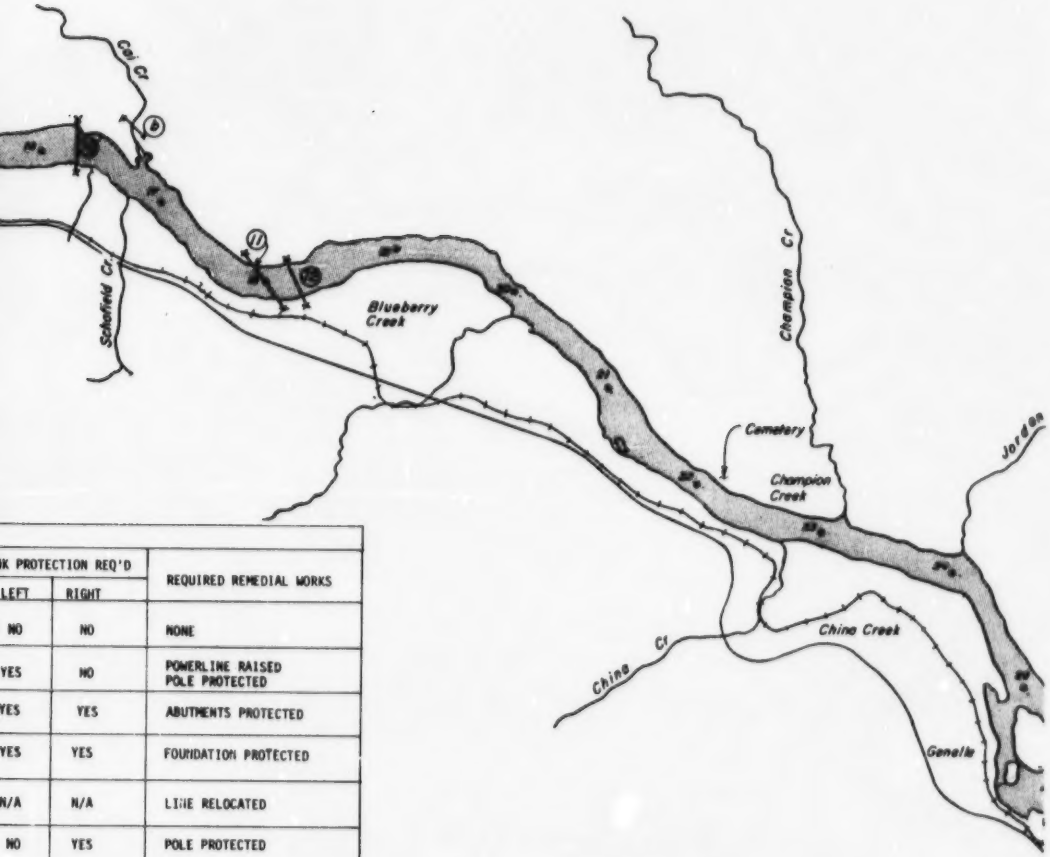
SHORELINE PROTECTION WORKS

DATE	NOV 1982	FIG. 5-2	R
DWN	PK	DWG No.	218-C14-U429



RESERVOIR CROSSINGS

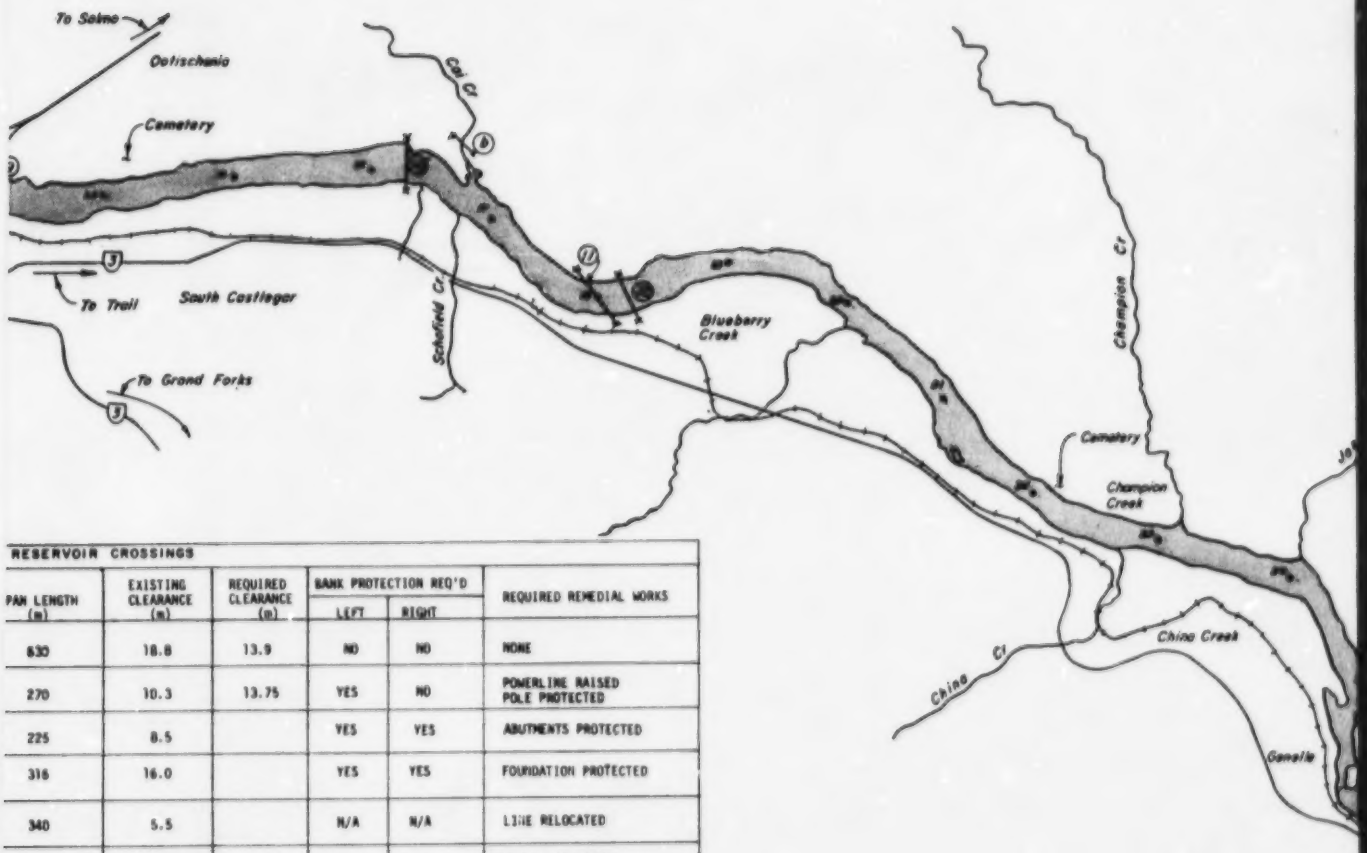
CROSSING NO.		CROSSING TYPE	LOCATION (km) FROM KEENLEYSIDE DAM	SPAN LENGTH (m)	EXISTING CLEARANCE (m)	REQUIRED CLEARANCE (m)
①		W.K.P.L. 60 kV POWERLINE	1.1	630	18.8	13.9
②		W.K.P.L. 13 kV POWERLINE	8.0	270	10.3	13.75
③		C.P.R. RAILWAY BRIDGE	8.1	225	8.5	
④		INLAND GAS GAS PIPELINE	9.3	316	16.0	
⑤		B.C. TEL TELEPHONE CABLES (2)	10.2	340	5.5	
⑥		B.C. TEL TELEPHONE CABLE	10.9	415	15.1	
⑦	A	W.K.P.L. 110 kV POWERLINE	11.2	400	23.4	14.5
	B	W.K.P.L. 60 kV POWERLINE	11.2	400	23.4	13.9
⑧	A*	C.P. TELECON TELEGRAPH LINES	12.3	560	8.2	
	B	C.P. TELECON TELEGRAPH CABLE	12.3	560	6.7	
⑨		B.C. HIGHWAY DEPT. KINNAIRD HIGHWAY BRIDGE	13.2	365	41.6	
⑩		W.K.P.L. 13 kV POWERLINE	16.3	390	4.4	13.75
⑪		W.K.P.L. 60 kV POWERLINES (6 CIRCUITS)	18.0	490	7.2	13.9
⑫		W.K.P.L. 60 kV POWERLINES (2 CIRCUITS)	18.2	344	10.5	13.9
⑬		WATER GAUGE CABLE	28.9	305	5.7	
⑭		W.K.P.L. 4-60 kV POWERLINES 1-13 kV DISTRB. LINE	KOOTENAY RIVER	450	7.7 (1 CIRCUIT)	13.9
⑮		B.C. HIGHWAY DEPT, BRILLIANT HIGHWAY BRIDGE	KOOTENAY RIVER	300	24.0	
⑯		W.K.P.L. 60 kV POWERLINE (3 CIRCUITS)	KOOTENAY RIVER	525	30.0	13.9
⑰		B.C. HIGHWAY DEPT. OLD BRILLIANT SUSPENSION BRIDGE	KOOTENAY RIVER	120	16.1	
⑱		B.C. HIGHWAY DEPT. HIGHWAY BRIDGE	PASS CREEK (HORNS CREEK)	45	4.2	



K PROTECTION REQ'D		REQUIRED REMEDIAL WORKS
LEFT	RIGHT	
NO	NO	NONE
YES	NO	POWERLINE RAISED POLE PROTECTED
YES	YES	ABUTMENTS PROTECTED
YES	YES	FOUNDATION PROTECTED
N/A	N/A	LINE RELOCATED
NO	YES	POLE PROTECTED
NO	YES	POLE PROTECTED
NO	YES	LINES RAISED POLES PROTECTED
YES	YES	CABLE RAISED POLES PROTECTED
YES	YES	ABUTMENTS PROTECTED
YES	NO	POWERLINE RAISED POLE PROTECTED
NO	YES	POWERLINES RAISED POLES PROTECTED
NO	YES	POWERLINES RAISED POLES PROTECTED
YES	YES	REMOVED PRIOR TO PROJECT
YES LINES)	NO	DISTRIBUTION CIRCUIT LINE RAISED. POLES RAISED
NO	NO	NONE
NO	NO	NONE
NO	NO	NONE
NO	NO	NONE

* W.K.P.L. LINE WITH RED AND WHITE STRIPED POLES USED BY CP TELECOMMUNICATION

RESERVOIR IMPACTS ON UTILITY LINES:	
LINE IDENTIFICATION	REQUIRED REMEDIAL WORK
ⓐ SELKIRK COLLEGE-DRIVE IN	2 POLES PROTECTED
ⓑ WATERLOO EDDY	20 POLES RAISED & 28 POLES PROTECTED



RESERVOIR CROSSINGS

SPAN LENGTH (m)	EXISTING CLEARANCE (m)	REQUIRED CLEARANCE (m)	BANK PROTECTION REQ'D		REQUIRED REMEDIAL WORKS
			LEFT	RIGHT	
630	18.8	13.9	NO	NO	NONE
270	10.3	13.75	YES	NO	POWERLINE RAISED POLE PROTECTED
225	8.5		YES	YES	ABUTMENTS PROTECTED
316	16.0		YES	YES	FOUNDATION PROTECTED
340	5.5		N/A	N/A	LINE RELOCATED
415	15.1		NO	YES	POLE PROTECTED
400	23.4	14.5	NO	YES	POLE PROTECTED
400	23.4	13.9			
560	8.2		NO	YES	LINES RAISED POLES PROTECTED
560	6.7		YES	YES	CABLE RAISED POLES PROTECTED
365	41.6		YES	YES	ABUTMENTS PROTECTED
390	4.4	13.75	YES	NO	POWERLINE RAISED POLE PROTECTED
490	7.2	13.9	NO	YES	POWERLINES RAISED POLES PROTECTED
344	10.5	13.9	NO	YES	POWERLINES RAISED POLES PROTECTED
305	5.7		YES	YES	REMOVED PRIOR TO PROJECT
450	7.7 (1 CIRCUIT)	13.9	YES (2 LINES)	NO	DISTRIBUTION CIRCUIT LINE RAISED. POLES RAISED
300	24.0		NO	NO	NONE
525	30.0	13.9	NO	NO	NONE
120	16.1		NO	NO	NONE
45	4.2		NO	NO	NONE

* W.K.P.L. LINE WITH RED AND WHITE STRIPED POLES USED BY CP TELECOMMUNICATION

RESERVOIR IMPACTS ON UTILITY LINES:	
LINE IDENTIFICATION	REQUIRED REMEDIAL WORK
(a) SELKIRK COLLEGE-DRIVE IN	2 POLES PROTECTED
(b) WATERLOO EDDY	20 POLES RAISED & 28 POLES PROTECTED

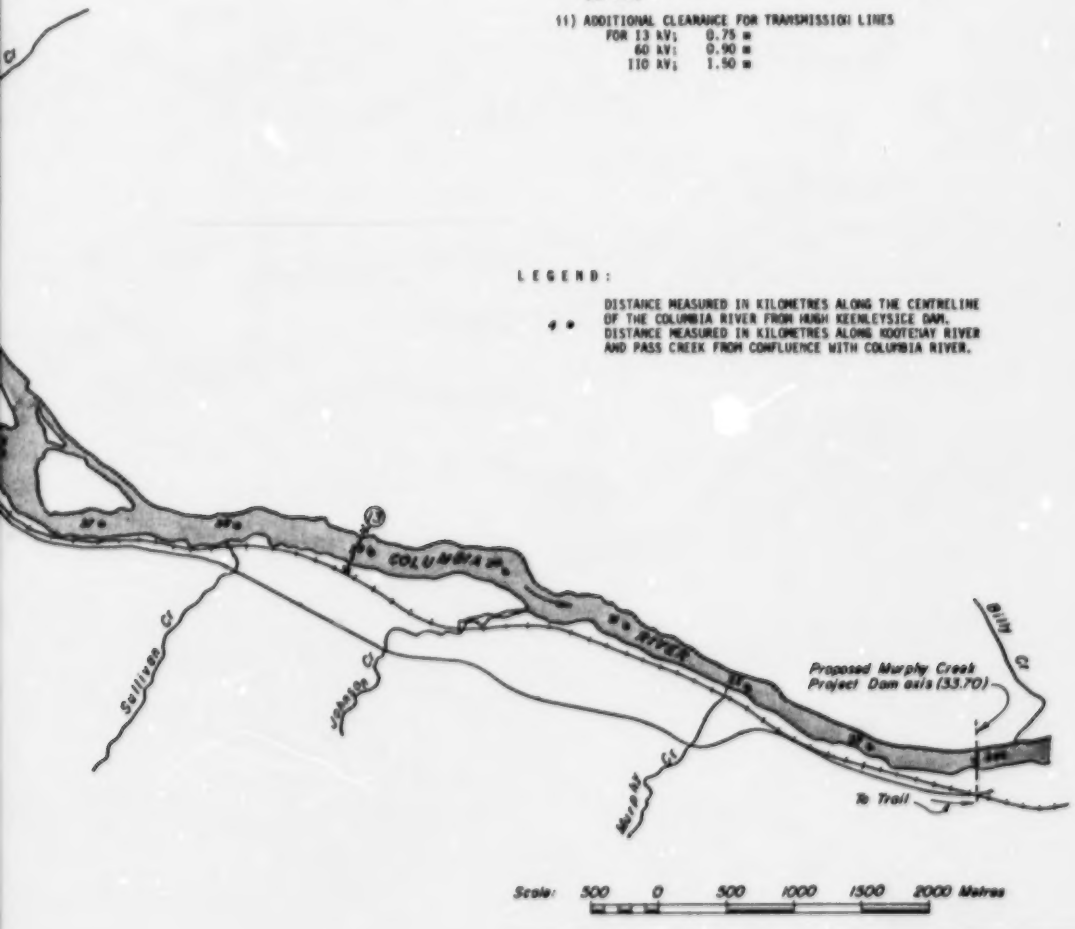
NOTES:

1. EXISTING CLEARANCES ARE BASED ON RESERVOIR LEVEL, EL 424 m.
2. REQUIRED CLEARANCES ARE:
   i) BASIC CLEARANCE OF 13.0 m OVER RESERVOIR LEVEL, (EL 424)
   ii) ADDITIONAL CLEARANCE FOR TRANSMISSION LINES
   FOR 13 kV: 0.75 m
   60 kV: 0.90 m
   110 kV: 1.50 m

LEGEND:

DISTANCE MEASURED IN KILOMETRES ALONG THE CENTRELINE OF THE COLUMBIA RIVER FROM HUGH KEENLEYSIDE DAM.

DISTANCE MEASURED IN KILOMETRES ALONG KOOTENAY RIVER AND PASS CREEK FROM CONFLUENCE WITH COLUMBIA RIVER.

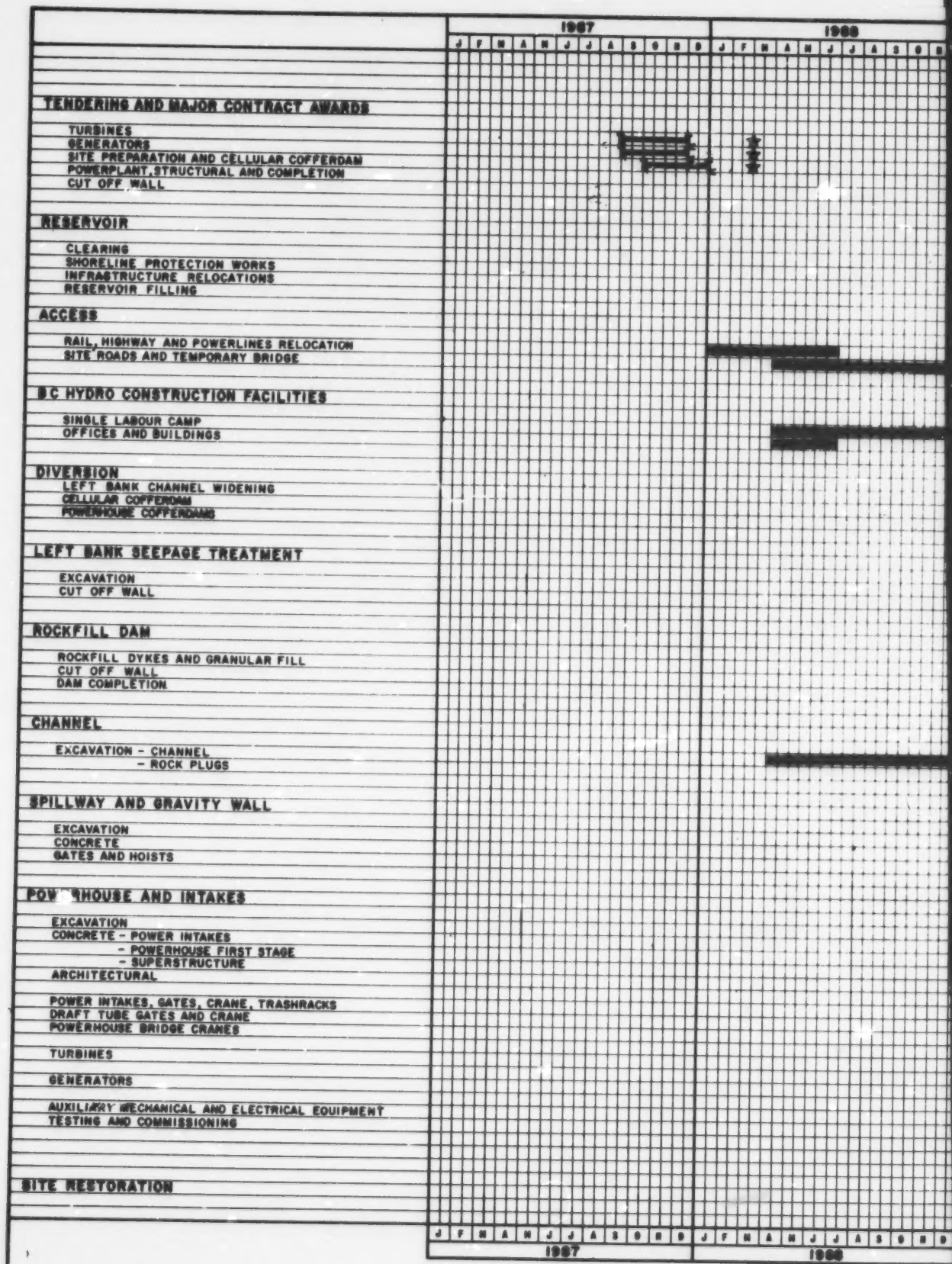


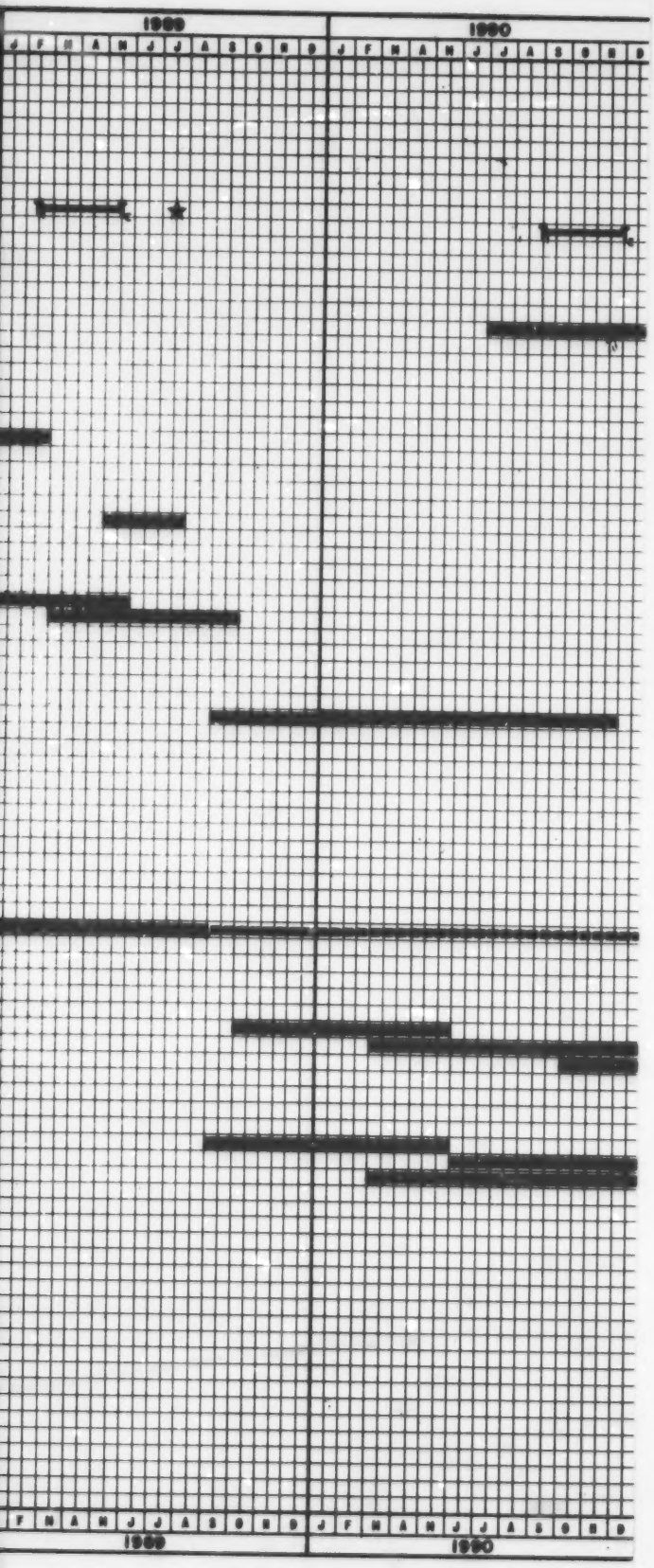
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

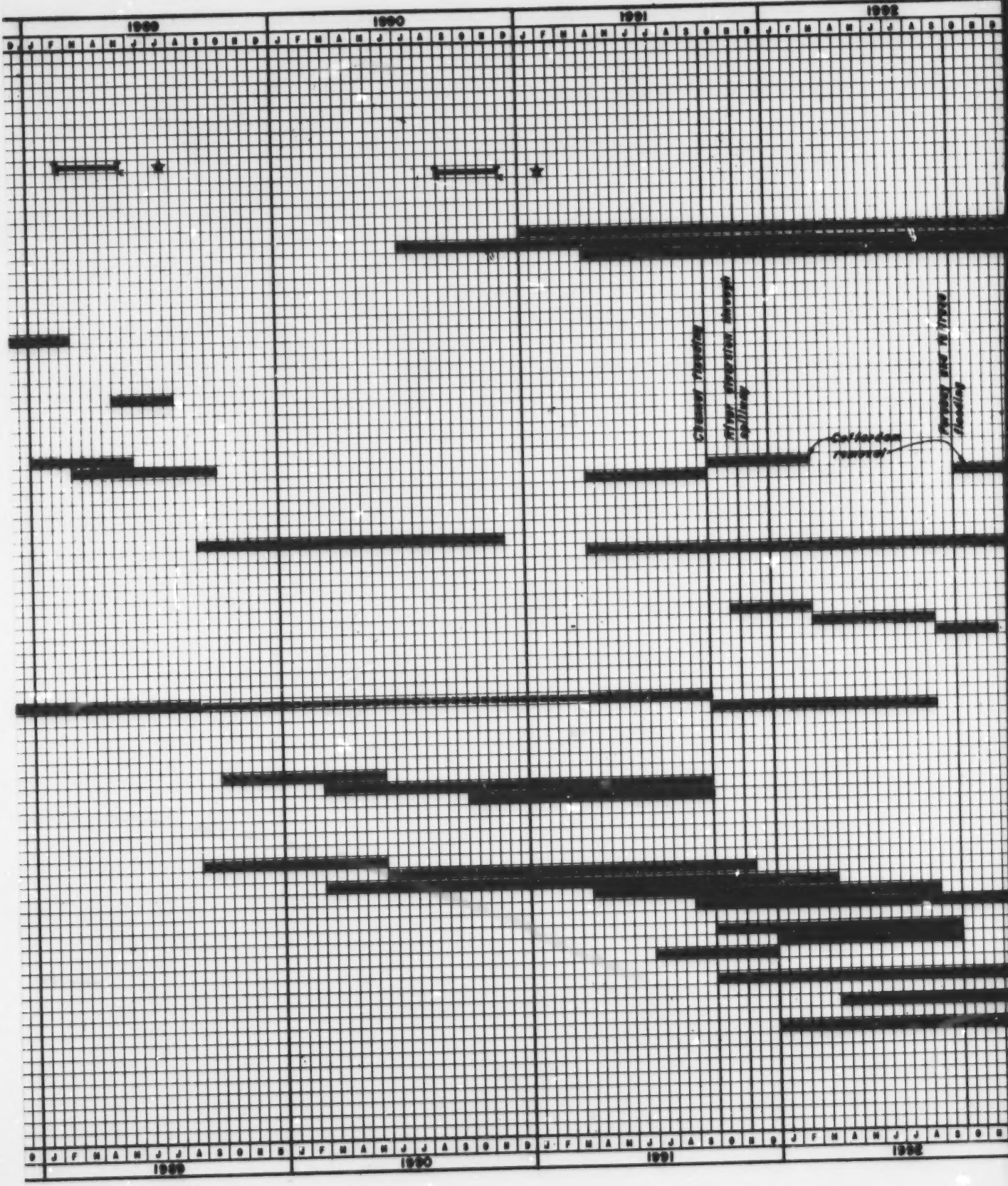
COLUMBIA RIVER - MURPHY CREEK PROJECT

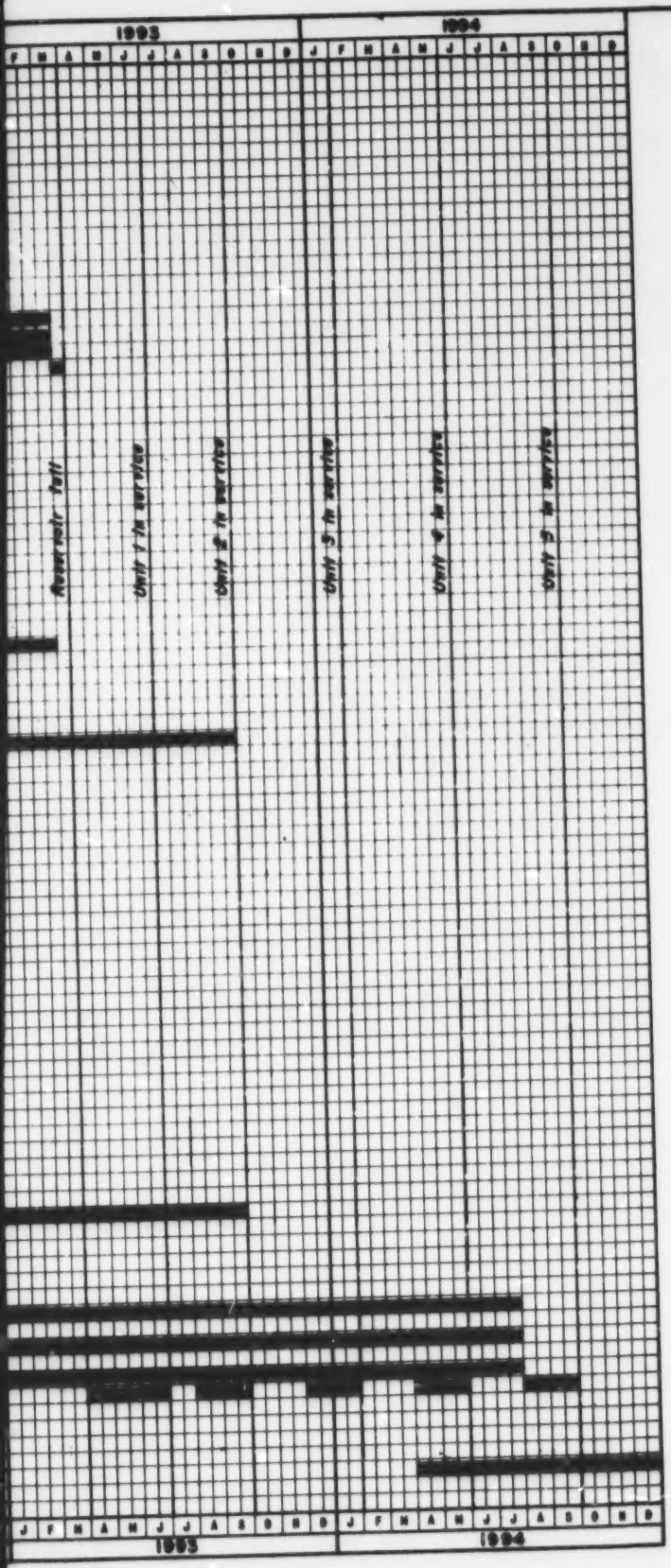
RESERVOIR CROSSINGS

DATE	NOV 1982	FIG. 5-3	R
DWN	AKW	DWG No. 218-C14-U484	


1987
1988
J F M A M J J A S O N D
TENDERING AND MAJOR CONTRACT AWARDS
TURBINES
GENERATORS
SITE PREPARATION AND CELLULAR COFFERDAM
POWERPLANT, STRUCTURAL AND COMPLETION
CUT OFF WALL
RESERVOIR
CLEARING
SHORELINE PROTECTION WORKS
INFRASTRUCTURE RELOCATIONS
RESERVOIR FILLING
ACCESS
RAIL, HIGHWAY AND POWERLINES RELOCATION
SITE ROADS AND TEMPORARY BRIDGE
BC HYDRO CONSTRUCTION FACILITIES
SINGLE LABOUR CAMP
OFFICES AND BUILDINGS
DIVERSION
LEFT BANK CHANNEL WIDENING
CELLULAR COFFERDAM
POWERHOUSE COFFERDAMS
LEFT BANK SEEPAGE TREATMENT
EXCAVATION
CUT OFF WALL
ROCKFILL DAM
ROCKFILL DYKES AND GRANULAR FILL
CUT OFF WALL
DAM COMPLETION
CHANNEL
EXCAVATION - CHANNEL
- ROCK PLUGS
SPILLWAY AND GRAVITY WALL
EXCAVATION
CONCRETE
GATES AND HOISTS
POWERHOUSE AND INTAKES
EXCAVATION
CONCRETE - POWER INTAKES
- POWERHOUSE FIRST STAGE
- SUPERSTRUCTURE
ARCHITECTURAL
POWER INTAKES, GATES, CRANE, TRASHRACKS
DRAFT TUBE GATES AND CRANE
POWERHOUSE BRIDGE CRANES
TURBINES
GENERATORS
AUXILIARY MECHANICAL AND ELECTRICAL EQUIPMENT
TESTING AND COMMISSIONING
SITE RESTORATION
J F M A M J J A S O N D
1987
1988


1989
1990
J F M A M J J A S O N D
J F M A M J J A S O N D
J F M A M J J A S O N D
J F M A M J J A S O N D
1989
1990


1989
1990
1991
1992
Cofferdam removal


1993
1994
F M A M J J A S O N D J F M A M J J A S O N D
Reservoir full
Unit 1 in service
Unit 2 in service
Unit 3 in service
Unit 4 in service
Unit 5 in service
J F M A M J J A S O N D J F M A M J J A S O N D
1993
1994

NOTES:

1. PROJECT APPROVAL REQUIRED AT LEAST SEVEN MONTHS PRIOR TO AWARD OF TURBINE CONTRACT.

LEGEND:

T_1 TENDER ISSUE

T_2 TENDER CLOSE

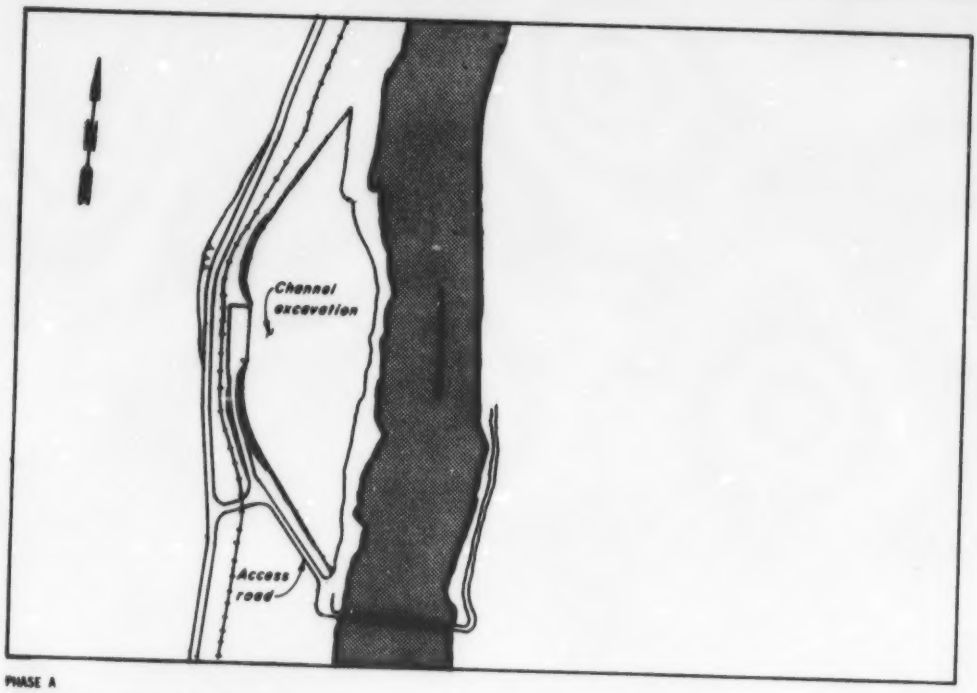
★ CONTRACT AWARD

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

COLUMBIA RIVER - MURPHY CREEK PROJECT

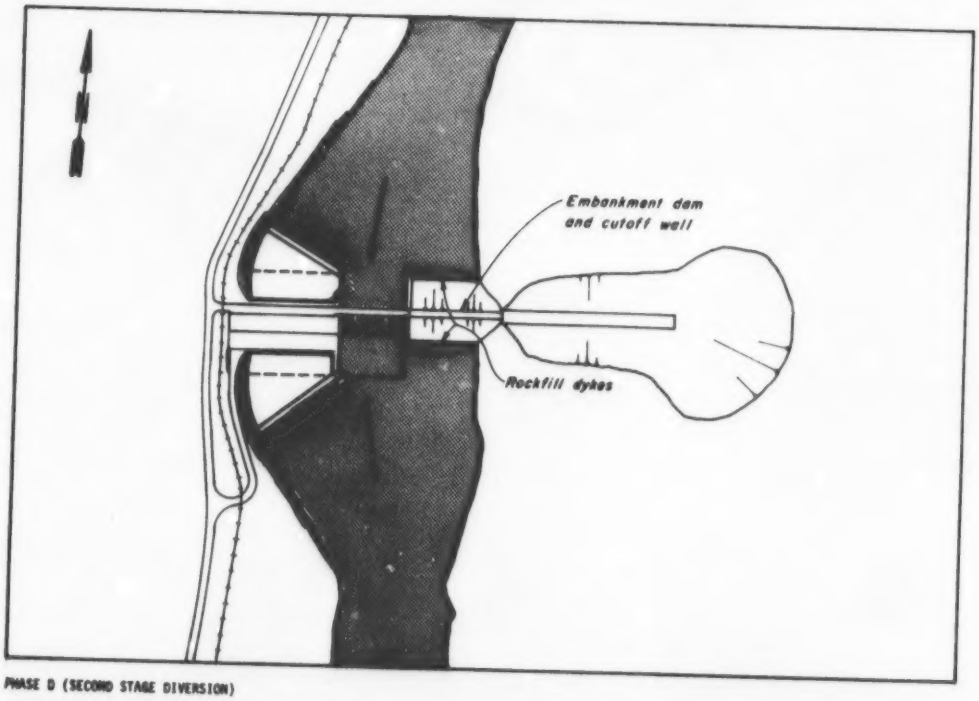
CONSTRUCTION SCHEDULE

DATE NOV 1982	FIG. 6-1	R
DWN JE	Dwg No. 218-C14-E430	



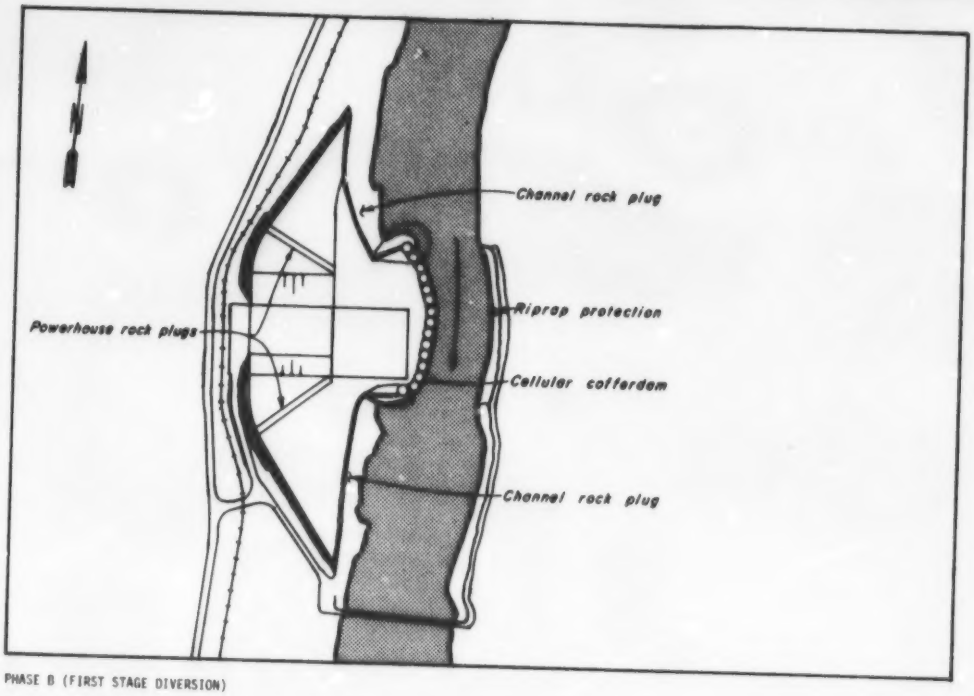
PHASE A

-RELOCATE TRANSMISSION LINES, ROAD, RAIL
-BUILD SITE ACCESS ROADS, TEMPORARY BRIDGE AND PREPARE WORK AREAS
-EXCAVATE CHANNEL TO EL. 412



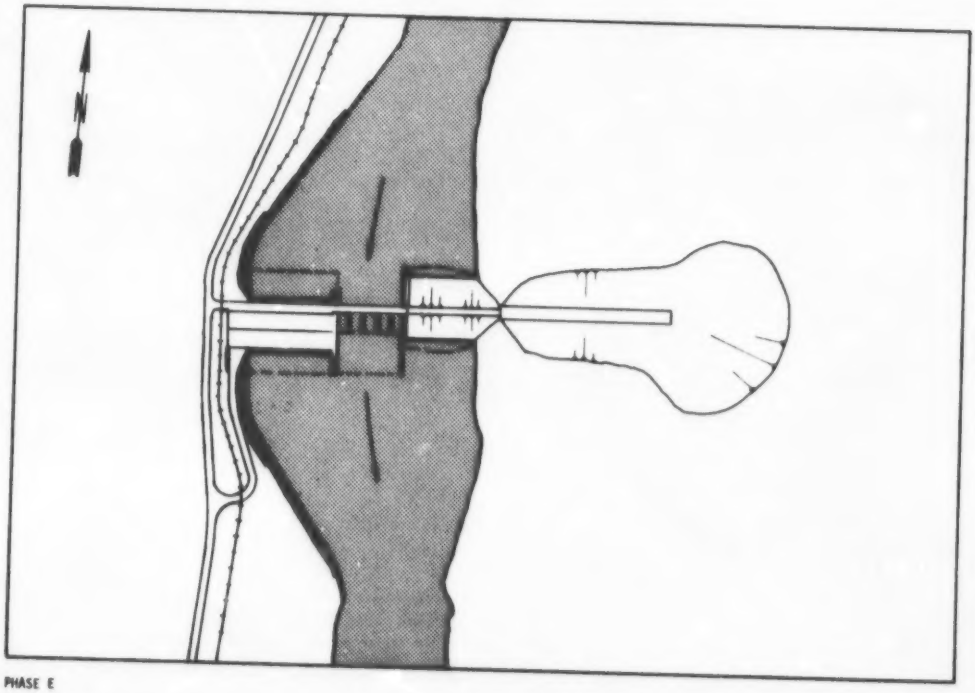
PHASE D (SECOND STAGE DIVERSION)

-REMOVE CELLULAR COFFERDAM AND CHANNEL ROCK PLUGS
-DIVERT RIVER
-CONSTRUCT THROUGH SPILLWAY ROCKFILL DYKES AND PLACE GRANULAR FILL
-COMPLETE CUTOFF WALL
-COMPLETE EMBANKMENT DAM CONSTRUCTION
-COMPLETE POWERHOUSE
-REMOVE TEMPORARY BRIDGE



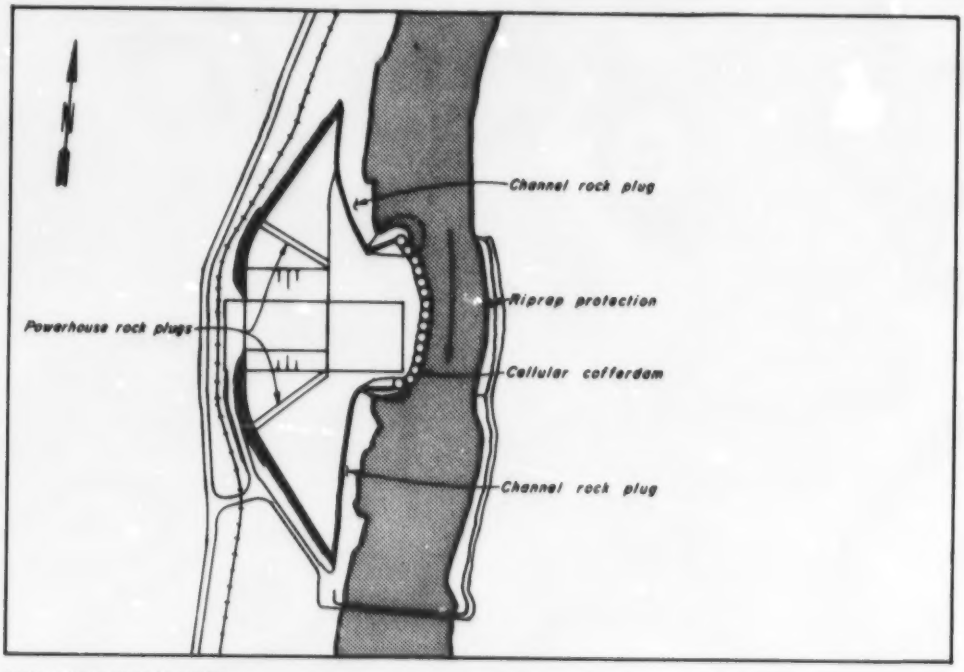
PHASE B (FIRST STAGE DIVERSION)

-WIDEN RIVER CHANNEL AND PLACE LEFT BANK RIPRAP PROTECTION
-CONSTRUCT CELLULAR COFFERDAM
-EXCAVATE SPILLWAY AND POWERHOUSE
-COMPLETE CHANNEL EXCAVATION EXCEPT FOR CHANNEL AND POWERHOUSE ROCK PLUGS



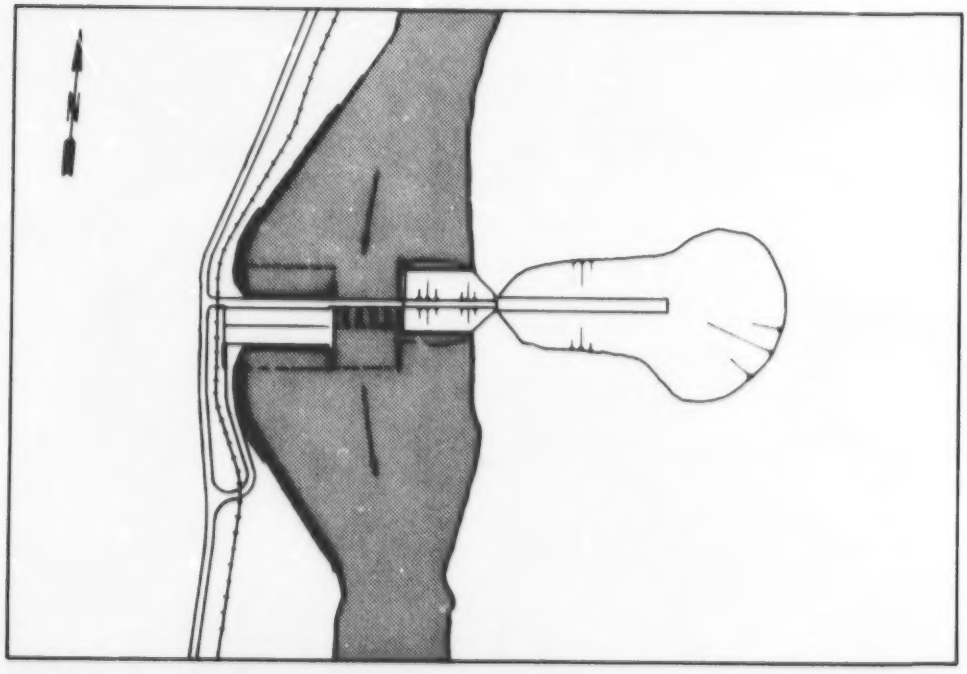
PHASE E

-REMOVE POWERHOUSE ROCK PLUG COFFERDAMS
-FILL RESERVOIR



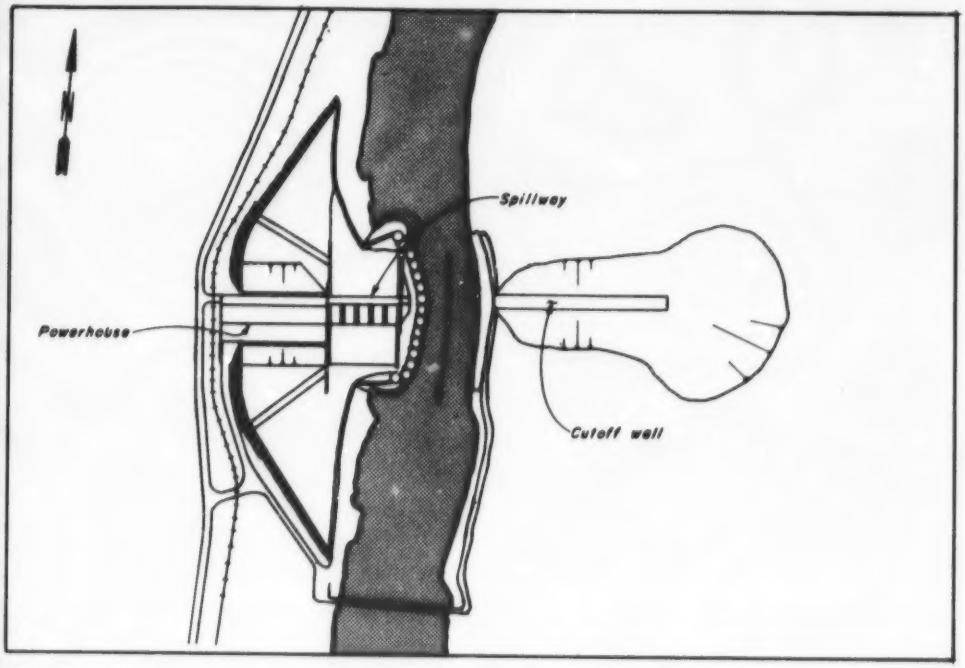
PHASE B (FIRST STAGE DIVERSION)

-WIDEN RIVER CHANNEL AND PLACE LEFT BANK RIPRAP PROTECTION
-CONSTRUCT CELLULAR COFFERDAM
-EXCAVATE SPILLWAY AND POWERHOUSE
-COMPLETE CHANNEL EXCAVATION EXCEPT FOR CHANNEL AND POWERHOUSE ROCK PLUGS



PHASE E

-REMOVE POWERHOUSE ROCK PLUG COFFERDAMS
-FILL RESERVOIR

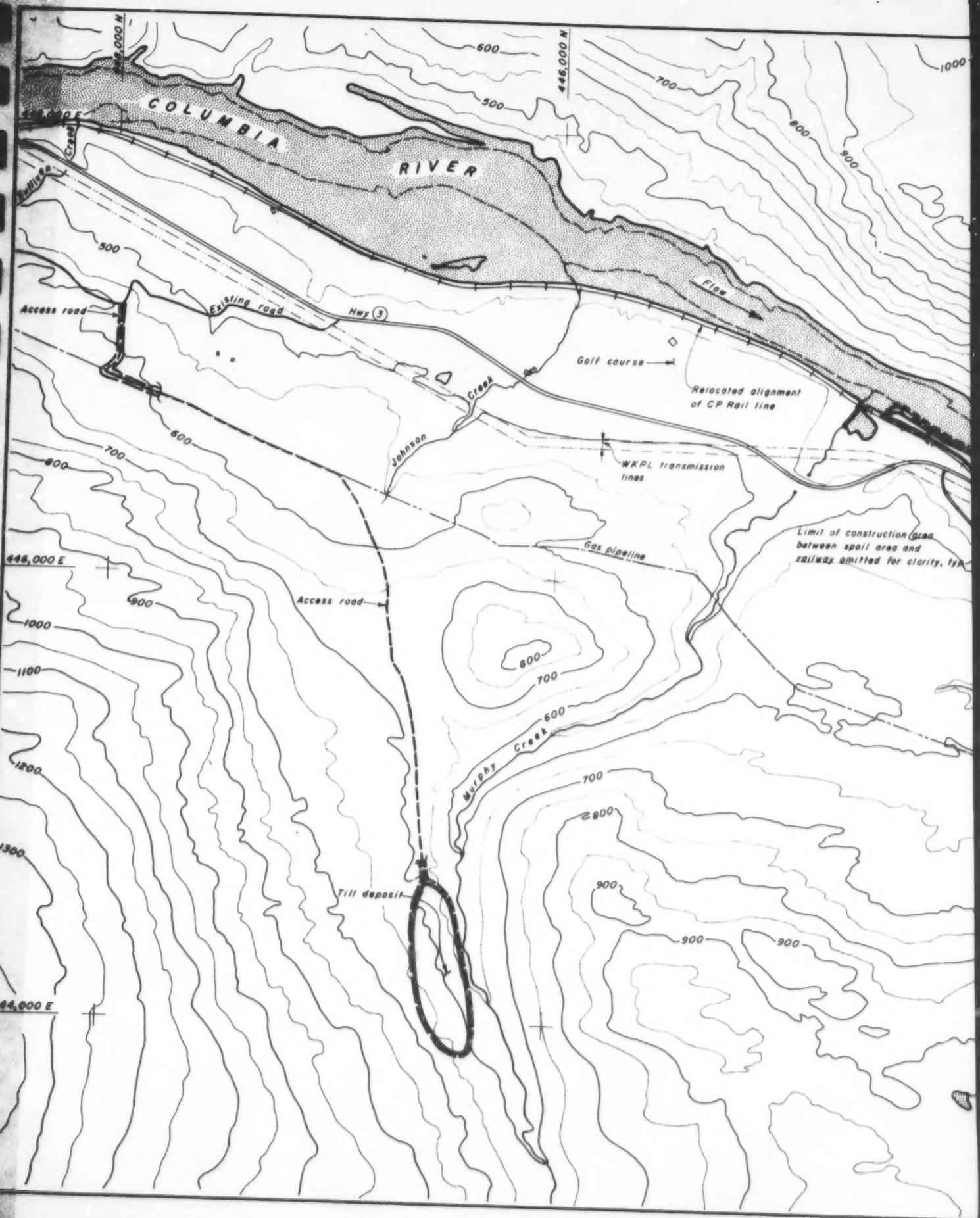


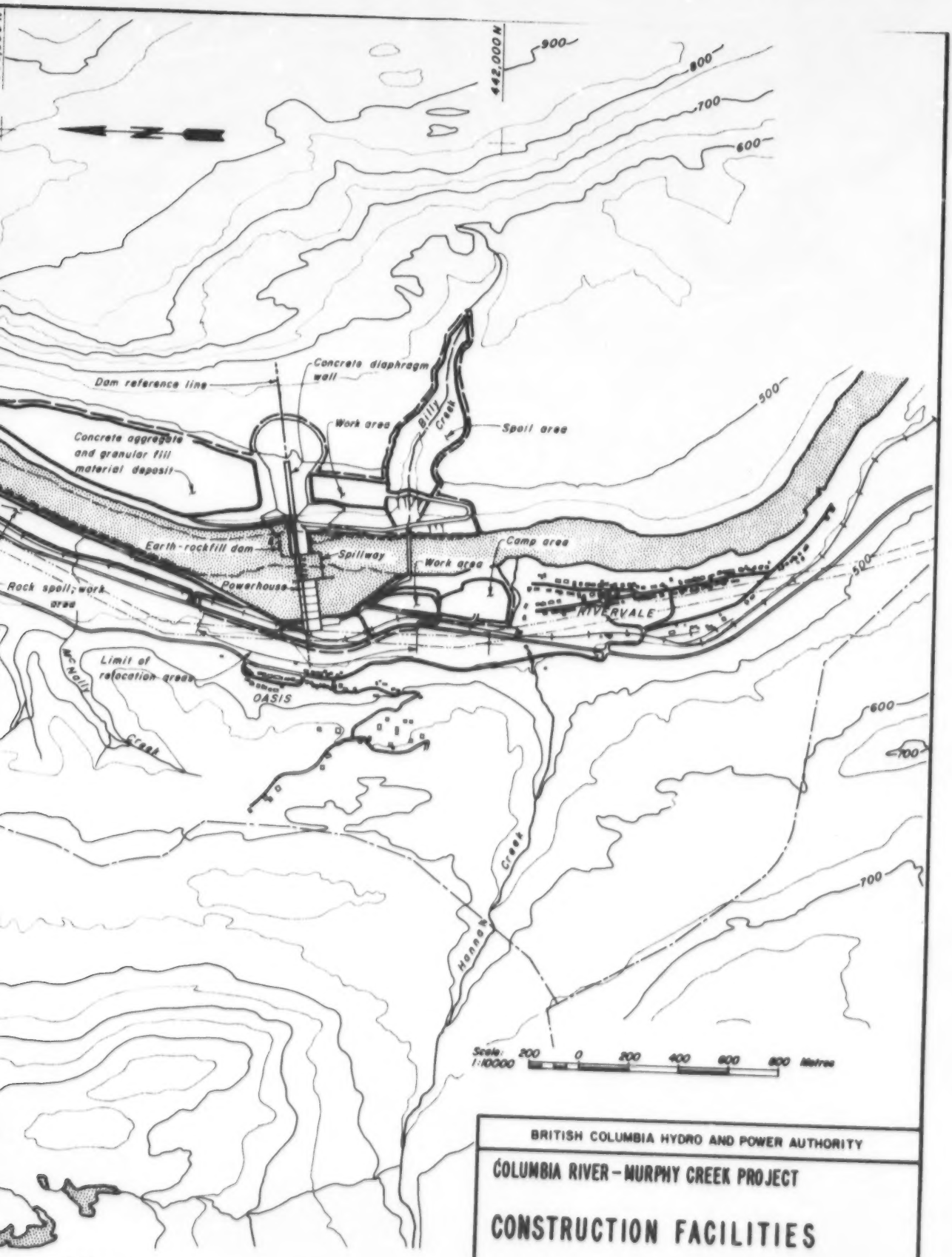
PHASE C

- CONSTRUCT POWERHOUSE AND SPILLWAY STRUCTURES
- INSTALL SPILLWAY GATES
- EXCAVATE LEFT BANK OVERBURDEN MATERIAL
- CONSTRUCT LEFT BANK CUTOFF WALL

Scale: NTS

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY		
COLUMBIA RIVER - MURPHY CREEK PROJECT		
CONSTRUCTION AND RIVER DIVERSION SEQUENCE		
DATE NOV 1982	FIG. 6-2	R
DWN P. K.	DWG No. 218-C14-U423	


COLUMBIA
RIVER
446,000 N
446,000 E
444,000 E
Creek
Access road
Existing road
Hwy 3
Flow
Golf course
Relocated alignment of CP Rail line
Johnson Creek
WKPL transmission lines
Gas pipeline
Limit of construction area between spoil area and railway omitted for clarity, typ.
Access road
Murphy Creek
Till deposit
500
600
700
800
900
1000
1100
1200
1300



BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

COLUMBIA RIVER - MURPHY CREEK PROJECT

CONSTRUCTION FACILITIES

DATE	NOV 1982	FIG. 6-3	R
DWN	MWB	DWG No.	218-C14-D483